Railway Mechanical Engineer

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Competition on Car Inspection

One of the most important branches of the work of the car department is the inspection of cars to ascertain whether they are in need of repairs or whether they are fit for a certain class of freight. The expense of performing this work is a fairly large item and the inspection has such a direct effect on the safety and economy of operation, that it is a matter which requires constant attention. In order to bring out information regarding the methods used in handling the inspection of freight cars on various roads, the *Railway Mechanical Engineer* offers a first prize of $50 and a second prize of $35 for the best articles dealing with this subject that are received before March 30, 1923. The articles may be of a general nature or may cover some special phase of car inspection, such as the methods of inspection in train yards, locating defects in wheels and trucks, inspection of cars for grain loading, etc. The articles will be rated according to the practical value of the methods described and the ideas presented, and not on the basis of literary merit. In addition to the prizes mentioned above, any other articles that are published in the *Railway Mechanical Engineer* will be paid for at regular space rates. Articles entered in this competition should be mailed to the Managing Editor, *Railway Mechanical Engineer*, Woolworth Building, New York City, early enough to reach our office before March 30.

The Value of Exchanging Ideas

The rapid growth of civilization has been almost directly proportional to man's success in devising ways and means to communicate with his fellows. First verbally, then by writing and printing, then by the telephone and telegraph, and finally by radio, men learned to exchange opinions and ideas, thereby contributing in no small measure to the rapid development of national life and industry. Until the comparatively recent invention, enabling messages to be broadcasted by radio to thousands, if not millions, of people, the printed word was most effective in reaching a wide circulation. Nor has this form of communication lost its power, and thinking people realize, therefore, the important function of a technical paper like the *Railway Mechanical Engineer* in disseminating knowledge which will not only help its readers in their work, but keep them posted regarding the latest news and developments in their particular line.

Most men realize the importance of this work, but unfortunately some do not. The latter frequently fail to read technical papers and profit by the information so readily available. They never submit their experiences for publication and thereby increase the general store of knowledge. It is reported that in a specific case a railroad man, who should have known better, made the remark that his road had tried out a certain piece of apparatus at a cost of $8,000 and he did not propose to make the results of those tests available to other railroad men who would thereby get the information without cost. "Let them find out for themselves," he is quoted as saying. If Columbus, for example, had taken this attitude, where would we be in 1923?

Railroad men should not only exchange ideas verbally among themselves, but they should read the books and technical papers most closely allied with their work, contributing regularly for publication such ideas regarding the work as they think will be of general interest and value. The importance of this practice is aptly indicated in the words of A. W. Shaw: "You have an idea. I have an idea. We swap. Now you have two ideas, and I have two ideas." There is no way of getting around this logic. In few other human transactions can two people give each other something and yet each have more than at first.

Balance the Grinding Wheels

In view of their relatively small experience with grinding machines, some railroad shop men probably do not realize the necessity of balancing the grinding wheels with the greatest care. This should be done whether the wheels are used on common floor grinders or on the heaviest surface grinding machine. It should be done whenever a new wheel is first applied as a check on the manufacturers' balancing, and it should be done at intervals during the life of the wheel, since cases have been known where a perfectly balanced new wheel became out of balance when half worn out. While vibration can be caused by other defects, such as loose bearings, building vibration, revolving parts out of balance, lack of proper steady-rests, etc., unbalanced grinding wheels are probably the most common cause of vibration and chatter marks on work which is being ground. The unbalanced wheel is wasteful of power, produces rough work and will eventually break with possible serious results, if the vibration becomes severe enough. Obviously these reasons are of sufficient importance to warrant the most careful attention to grinding wheel balance.

The most natural place for an operator to look when he discovers chatter marks on ground work is at the spindle bearings of the grinding machine. While these bearings should be under constant surveillance, it must be remembered that the wheel spindle requires sufficient play in the bearings to permit a film of oil to be retained for purposes of lubrication. If the spindle bearings are unduly tightened in an attempt to prevent chatter marks caused by an unbalanced wheel, the spindle will bind and heat.

If chatter marks are not caused by loose bearings, improperly adjusted steady-rests, or building vibration, the grinding wheel should be carefully checked for balance, preferably mounted on its spindle. The common method is to support the wheel spindle on parallel, horizontal ways along which the spindle can roll if it is not correctly balanced. If the wheel is out of balance, correction can be made by chipping out a certain amount of material at the right point on the wheel. In large hole wheels a lead insert is sometimes provided and the wheel can then be balanced by drilling out or adding a slight amount of lead as needed.

In still other large hole wheels balancing can be accomplished by means of an adjustable lead tubing on a wire enclosed within the keyed driving flanges. In view of the importance of correctly balanced grinding wheels in attaining smooth work and reducing the possibility of danger to operators it will pay to make arrangements for the systemmatic and careful check of grinding wheel balance.

Advantages of Outside End-Sills

When cars were built entirely of wood, many were constructed with the end-sills extending beyond the body, because this so-called outside or platform end-sill facilitated repairs. It also had an important advantage in operation because it made it easy for the trainman to go from one side of the car to the other. Since the adoption of steel underframes, end-sills do not require frequent repairs and the outside sill has largely gone out of use. It is still an open question, however, whether this construction is not desirable even under present conditions. The men who work in the yards frequently have to go from one side of a train to the other and it is also necessary for trainmen to cross over at times in road service. While ladders are provided so that men can go over the top of the cars, this method is so inconvenient that they will usually step across on the couplers. There are no handholds required near the center of the car and there is no place that gives a good footing so it is often dangerous to cross between the cars unless they have platform end-sills. There are certainly some advantages in outside end-sills from the operating standpoint but it is largely a matter of judgment whether the additional cost of such construction is justified, for it would necessarily require a slightly longer underframe. As a rule, car designers consider that standard safety appliances make cars convenient and safe for switchmen and trainmen and little attention is given to features of construction that might make a car more attractive to the men on the road. In some cases the operating department is very insistent on the use of platform end-sills and if the transportation men were consulted in the matter it is probable that they would be found practically unanimous in favor of such construction.

Standardization by Preferred Sizes

At the recent meeting of the American Society of Mechanical Engineers a paper was presented on the subject of size standardization by preferred numbers. This is a matter which has not been given much attention in this country, but seems to offer possibilities for simplification and for elimination of waste that should be carefully considered in buying railroad equipment. The authors point out that the choice of sizes used in industry and commerce in most cases is arbitrary, and that slight variations in the sizes finally decided upon are, as a rule, of little importance. For instance, in designing a bearing, the area is first determined, which leads to the choice of suitable diameters and lengths. Suppose the length is selected arbitrarily and the corresponding diameter is found to be 1.70 in., or approximately 1-45/64. The designer must now decide whether he shall reduce the size to 1-11/16 in., or whether he shall increase it to 1-23/32, or to get a more common size, to 1¾ in. Different men have different ideas as to the permissible variation from calculated dimensions and the result is an almost limitless number of sizes.

If certain dimensions are accepted as preferred values, and spaced to fit ordinary requirements, choices may be made in these preferred sizes and a considerable degree of standardization accomplished with little effort. This idea has already been applied to some extent—for instance, in driving wheel centers, although in this instance the size intervals are not logical. The most satisfactory arrangement is to have each size increased in a definite ratio over the one before. For instance, a preferred number system which has been adopted in Germany has several ratios in which each size increases over the preceding size by approximately 60 per cent, 26 per cent, 12 per cent, 6 per cent, and 3 per cent. A series of preferred sizes increasing in geometric progression may be too great a departure from the existing system to be adopted at the present time, but the idea of standardizing the minimum number of sizes in order to facilitate interchangeable manufacturing is readily applied, and merits thorough consideration.

Machining Shoes and Wedges

One of the most important jobs in all locomotive shops is machining shoes and wedges. Formerly this operation was almost always done on the planer, which was a slow and troublesome process. Sometimes the castings were set up three different times to finish the channel and the two sides. Regardless of the method used, it is difficult to finish the channel properly. Shoes and wedges that are to be machined on a planer should be set with the flanges up and a multiple cutter used to finish the four faces at the same time. Even with this method, the time lost while setting up and removing the work and during the return stroke of the table is excessive.

The best method of finishing shoes and wedges is, unquestionably, to use a milling machine. Either the planer type or the knee type can be used. The cutters can readily be arranged to mill the channel and the outside of the flanges at the same time, and since the cutters enter the castings under the scale, they do not become dull as quickly as planer tools. If shoes and wedges are set up in gangs on a planer type milling machine, they can be attached or removed from the fixture while the machine is cutting, thus reducing the idle time of the machine to a minimum. The one thing to be guarded against in milling shoes and wedges is damage to the cutters. Both the solid type and the inserted type cutters are costly, and if they are spoiled the economy of the method is offset by the cost of replacing them. Bronze shoes and wedges often contain small amounts of sand which soon dull the cutters, making it impractical to finish them by milling. However, where either cast iron or cast steel shoes and wedges are used, if the metal is of the proper composition and the castings are reasonably clean, a high cutting speed can be used, and milling will be found by far the best method for finishing these parts.

Modern Shop Machinery Needed

While the railroads have inquired for and actually purchased a large number of new machine tools in the past few months, repair shops and enginehouses are still greatly deficient in modern machine equipment. This lack of up-to-date machinery handicaps the railroads, as pointed out in an article published elsewhere in this issue. The article discusses at some length the present machine deficiency, indicating the causes which have brought it about and suggesting some of the things which can be done to remedy it.

There is no question that the many obsolete and inefficient machines now used in railroad shops and enginehouses result in excessive repair costs and cause equipment to be held out of service, while waiting and undergoing repairs, longer than should be necessary. This has a direct and deleterious effect on revenue-earning capacity and therefore on net earnings. Owing to the fact that the machine department is usually the limiting factor in shop output, the condition of machine equipment is doubly important, a fact not always fully

appreciated. It may safely be said that money spent by the railroads for shop machinery in recent years has been insufficient to replace machines as fast as they became worn and out-of-date. Cars and locomotives, in the meantime, have increased in both number and size so that under present conditions the machine shop is more than ever the "neck of the bottle" of shop production.

The present condition of shop machinery can be readily realized from the fact that in shops of some of the most prosperous railroads, the machine tools are on an average 20 years old. These machines lack the power to push high-speed steel tools to anywhere near their capacity, and in consequence the cutting speeds and feeds must be reduced, with resultant increased labor costs. Labor costs are also increased by the difficulty, physical effort and inconvenience in operating old machines as compared to modern productive tools. It is highly important that the subject of machine shop equipment be given deeper study and thought than ever before by railroad men responsible for shop and enginehouse costs. In too many cases new equipment has been purchased without providing facilities, particularly machine equipment, for repairing it. As indicated in the article, a move toward overcoming this condition will be the preparation of intelligent machine tool programs or budgets showing just what new machines are needed and how much it is costing the railroads to get along without them.

Is Paint Spraying Dangerous?

It has long been the contention of painters' labor organizations that the use of paint-spraying equipment is dangerous to operators, and, in fact, bills to prohibit paint spraying are presented to the various state legislatures practically every year. An unusually strong effort is being made this year in California, Minnesota, Wisconsin and New York to secure the passage of legislation prohibiting the spraying of paint. The railroads have more than a passing interest in this matter. It is true that without proper safeguards the use of paint-spraying equipment is distasteful, if not dangerous. Proper ventilation must be provided to carry away fumes and, particularly in the case of paints having a lead base, protective covering is needed for the operator's mouth and nose. Lead paints must be handled with caution, however, even if applied with a brush, since it appears that lead in the human system acts as a poison whether inhaled or taken internally by a workman who eats lunch without properly cleaning his hands.

Protective devices have been developed and have proved effective in guarding the health of those who operate paint-spraying machines. Objections on this ground are therefore unfounded and, while the proposed legislation against paint spraying is disguised as a health measure, there is little doubt that the real objection on the part of the painters' labor organization is due to the fear which the handworker too often has of labor-saving machinery and devices. This fear was evidenced by opposition to the first sewing machine and the opposition to paint-spraying is just as foolish, and shows just as great a misunderstanding of the economics of the case.

Paint-spraying equipment greatly speeds up painting operations, reduces costs, and in the end will benefit not only painters but the entire community. Some hand painters may, and probably will, be released to other gainful occupations, but they and their neighbors will in the long run enjoy a higher standard of living in proportion to the labor saved. Manufacturers of paint-spraying equipment are vigorously opposing anti-spraying legislation, and the railroads should stand ready to assist in this opposition, providing affidavits as needed to prove the savings effected by paint spraying and the absence of ill effects with the use of suitable protective devices.

THE QUESTION BOX

Reboring Cylinder Head Counterbore

Question.—I should like to have suggestions as to the best method for reboring of the counterbore for the piston rod packing in a locomotive back cylinder head, with an air motor and boring bars. I am especially interested in the method of feeding the tool. An attachment to go on a cylinder reboring machine would not answer the purpose, as no such device is available in this shop.—C. J. McDANIEL.

[The *Railway Mechanical Engineer* will be glad to receive suggestions from any reader regarding the most satisfactory device for doing this work, and will pay the regular space rate for description and blue-print which are published in answer to this inquiry.]

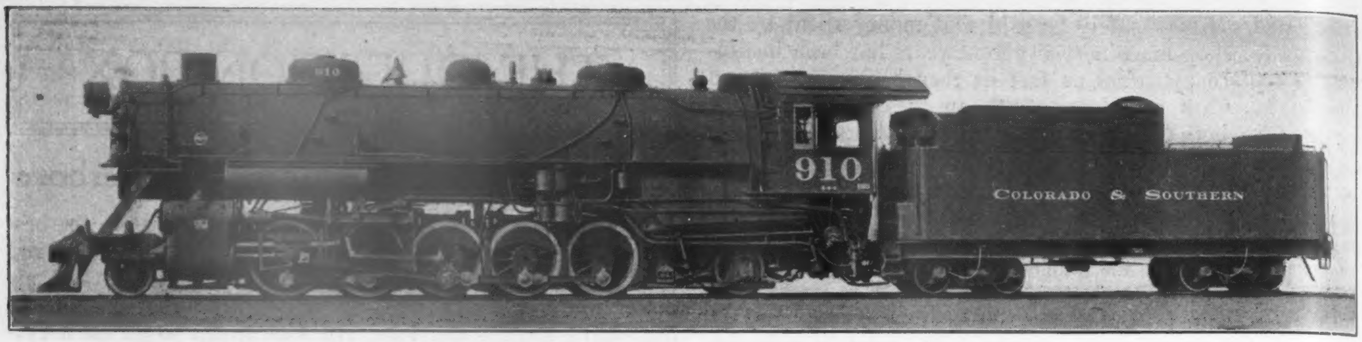
New Books

PROCEEDINGS OF THE INTERNATIONAL RAILWAY FUEL ASSOCIATION, 1922. *J. G. Crawford, Secretary, 702 East 51st street, Chicago. 352 pages, 6 in. by 9 in. Bound in leather.*

The proceedings of the fourteenth annual convention of the International Railway Fuel Association which was held in Chicago, May 22 to 25 inclusive, 1922, contains much of permanent value. Among the many committee reports which were presented and discussed the following were the most important: Locomotive Feed Water Heaters; Front Ends, Grates and Ashpans; Firing Practice and Coal Storage. Many able individual papers were also presented. Among these may be mentioned the following: Effect of Tonnage Rating and Speed on Fuel Consumption, J. E. Davenport; Firing Oil-Burning Locomotives, E. H. Baker; Educational Work in Fuel Economy, D. C. Buell; Locomotive Fuel—The Life Blood of Transportation, G. M. Basford; Effect of Circulation on Locomotive Boiler Efficiency, F. G. Lister and Colloidal Fuel, L. D. Bates. Fuel conservation questions from many angles formed the subject of other addresses and discussions.

GRINDING WHEELS, MACHINES, METHODS. *By members of the executive and technical staffs of the Norton Company, Worcester, Mass., 387 pages, 5 in. by 7½ in., bound in cloth. Published by the Norton Company.*

This book is a notable contribution to the literature on grinding. It does not purport to give the last word in modern grinding practice because the art of grinding is continually in the process of expansion and refinement. It does, however, give a great amount of information regarding present practice in the manufacture of abrasives and the art of grinding. The subject matter is presented in a comprehensive, attractive form, being well illustrated and clearly written. Apparently no important phases of grinding are omitted, so the book forms a very complete text book on the subject. Many of the chapters will be found of great practical value for reference by all grinding machine operators including those in railroad shops. For example, the chapters on Selection of Grinding Wheels, Tool and Cutter Grinding, Machines for Precision Grinding, Efficient Production of Cylindrical Work, Steady-Rests, Internal Grinding and Care and Safe Use of Grinding Wheels may be mentioned. In fact, the entire book is replete with valuable general and detailed information on grinding. The book should be read by all grinding machine operators, being retained for reference after reading. Machine shop foremen should also read it for suggestions as to operations more economically performed by grinding than by present methods.



A Recent Design of 2-10-2 Type Locomotive for the Colorado & Southern

Large Orders for Equipment Placed in 1922

Locomotive Orders Best Since 1918; Freight Cars Eight Times 1921; Passenger Cars Almost Equal Total of Preceding Four Years

THE year 1922, especially the latter half, was noticeable for the placement of many large orders for greatly needed equipment. This movement was not confined to any section, but was participated in by practically every important railroad and also by many small ones.

That the marked revival in the purchase of cars and locomotives is not temporary, but is indicative of the intention of the railways to pursue a liberal policy in adding to their equipment as their earnings increase is evidenced by the plans which a number of roads have already made for the new year. Thus, the Illinois Central has appropriated $9,445,000 for the purchase of 190 locomotives; the Union Pacific has set aside $5,280,000 for 80 locomotives; the Norfolk & Western $4,600,000 for 46 locomotives; the Central Railroad of New Jersey $1,800,000 for 36 locomotives; the Chicago, Rock Island & Pacific $2,600,000 for 40 locomotives; the Pere Marquette $800,000 for 20 locomotives; the St. Louis Southwestern $740,000 for 15; the Western Pacific $330,000 for 6, and the San Antonio & Aransas Pass $75,000 for 3.

Among other roads the Baltimore & Ohio will receive 50 locomotives; the Atlantic Coast Line 45; the Denver & Rio Grande Western 25, and the Nashville, Chattanooga & St. Louis, 15. While much of this equipment has already been ordered, payment will be made this year and is, therefore, included in the 1923 budgets.

Similarly large expenditures are being made for the purchase of freight cars. The Norfolk & Western included in its budget $19,000,000 for 8,000 cars; the Illinois Central $16,323,000 for 7,700 cars; the Western Pacific $5,275,000 for 2,000 refrigerator cars, and the Chicago, Rock Island & Pacific $4,775,000 for 2,500, and the Union Pacific $4,225,000 as its share of the cost of 3,000 refrigerator cars for the Pacific Fruit Express; the Atlantic Coast Line will secure 4,300 cars; the Philadelphia & Reading 3,100 cars; the Baltimore & Ohio 3,000; the Cotton Belt 1,200; the Nashville, Chattanooga & St. Louis 1,000, and the Denver & Rio Grande Western 950.

Among the appropriations for passenger cars are those of the Central Railroad of New Jersey of $2,400,000 for 118; the Norfolk & Western $1,000,000 for 20; the Illinois Central $760,000 for 33, and the Chicago, Rock Island & Pacific $950,000 for 50 cars; while the Philadelphia & Reading will buy 115; the Baltimore & Ohio 84; the Atlantic Coast Line 50, and the Nashville, Chattanooga & St. Louis 15 cars.

The following equipment has been ordered by the Chesapeake & Ohio of which only a small part has been delivered: 58 locomotives, approximate cost $4,586,000; 5,620 freight cars, approximate cost $8,561,000 and 68 passenger cars, approximate cost $1,444,000. The 1923 budget of the Illinois Central included $26,500,000 for new cars and locomotives.

The above is not offered as a complete summary of the work contemplated on even the limited mileage from which reports have been received. Rather, it is offered as indicative of the plans which the roads as a whole are making as they are entering the new year. As such it demonstrates that the railways are planning more improvements than they have had in contemplation at this season in any recent year. From present indications 1923 should be an active year.

Locomotives Orders

Locomotives ordered in 1922 for service in the United States and Canada totaled 2,636 or 10 times the figure of 274 reported for 1921. These figures are the largest since 1918. The totals for 1916 and 1917 were also larger than in 1922.

The export business for 1922 was insignificant in comparison with that of recent years as will be noted from Table I. The only export orders of any size were 8 of the 4-8-2 type for the Argentine State Railways, 6 of the 4-6-2 type for the Chosen Railway (Korea), 10 electric locomotives for the Mexican Railway, 25 of the 2-8-2 type for the Patagonian Railway, 25 of the 2-8-0 type for the Polish State Railways and 10 of the 2-8-2 type for the Sorocabana Railway of Brazil. Considerable electric locomotive equipment was also ordered for the Norde Railway of Spain and the Paris-Orleans Railway of France.

TABLE I—ORDERS FOR LOCOMOTIVES SINCE 1915

Year	Domestic	Canadian	Export	Total
1915	1,612	....	850	2,462
1916	2,910	....	2,983	5,893
1917	2,704	....	3,438	6,142
1918	2,593	209	2,086	4,888
1919	214	58	989	1,170
1920	1,998	189	718	2,905
1921	239	35	546	820
1922	2,568	68	143	2,779

Prior to 1918, Canadian orders included under "Domestic."

The more important orders for the United States and Canadian railroads are shown in Table II which includes 60 roads. The balance was divided into small orders for a number of other roads, including 162 for industrial concerns.

The types of locomotives ordered is shown in Table III. Of the 2,486 locomotives for railroads service, 291 were for switching service. Of these, 73½ per cent or 214 were

of the 0-8-0 type and 25½ per cent or 74 were of the 0-6-0 type.

There were 1,573 locomotives of the types usually employed for freight service. The largest proportion, 1,231 or 78 per cent were of the 2-8-2 type. There were also 73 of the 2-8-0 type. Of the 10-wheel connected types there were 261 or 16½ per cent, 157 being of the 2-10-2 and 104 of the 2-10-0 type. While the 2-8-2 is the predominent type for main line freight service, the Philadelphia & Reading; Lehigh & New England; Western Maryland; Toledo, St. Louis & Western and Norfolk Southern ordered the 2-8-0 type. The Pennsylvania ordered 100 of the 2-10-0 type, while the conditions on portions of the Atchison, Topeka & Santa Fe; Chicago, Burlington & Quincy; Colorado & Southern; Illinois Central; Oregon Railway & Navigation and Union Pacific made the use of the 2-10-2 type advisable.

Orders were given for 116 Mallet locomotives, the majority being for road service. Among the roads specifying this type were the Chesapeake & Ohio; Norfolk & Western; Denver & Rio Grande Western and Union Pacific.

Of the types usually employed for passenger or express service there were orders for 480 locomotives; of these 299 or 62 per cent were of the 4-6-2 type and 158 or 33 per cent of the 4-8-2 type. Orders included only 4 of the old American type and none of the Atlantic type. Orders for the 4-6-2 type were placed by many roads, the largest being 45 for Atlantic Coast Line; 32 for Chicago & Northwestern; 30 for New York Central; 20 each for Northern Pacific and Erie and 15 each for Baltimore & Ohio; Big Four; Delaware, Lackawanna & Western and Pennsylvania. Orders for the 4-8-2 type included 39 for Union Pacific, 20 for Denver & Rio Grande Western, 16 for Canadian National, 15 for St. Louis & San Francisco, 15 for Los Angeles and Salt Lake, 12 for Norfolk & Western and 10 for Chicago, Rock Island & Pacific.

TABLE II—IMPORTANT LOCOMOTIVE ORDERS IN 1922

Type	0-6-0	0-8-0	2-8-0	2-8-2	2-10-0	2-10-2	Mallet	4-6-0	4-6-2	4-8-2
A. G. So.	..	..	..	10	..	..	..	..	..	..
A., T. & S. F.	..	..	..	15	..	26	..	..	10	8
At., C. L.	..	..	..	..	..	..	..	..	45	..
B. & O.	..	..	..	85	..	..	..	..	15	..
B. & A.	..	..	..	8	..	..	..	..	..	..
B. & M.	..	22	..	..	..	..	..	..	..	..
Can. Nat.	..	..	..	45	..	..	..	..	..	16
Cent. of N. E.	..	20	..	..	..	..	..	..	..	..
C. of Ga.	..	..	..	18	..	..	..	..	..	2
C. R.R. of N. J.	5	10	..	10	..	..	..	..	5	..
C. & O.	..	..	..	..	..	..	50	..	6	2
C. & El.	..	..	..	10	..	..	..	..	6	..
C. & N. W.	40	..	..	78	..	..	..	..	32	..
C. B. & Q.	..	..	..	82	..	10	..	..	..	8
C. M. & St. P.	..	..	..	100	..	..	..	..	..	..
C. R. I. & P.	..	..	..	30	..	..	..	..	..	10
C. N.-O. & T. P.	..	6	..	25	..	..	..	..	..	..
C. C. C. & St. L.	..	15	..	50	..	..	..	..	15	..
C. & S.	..	..	..	..	..	5	..	..	3	..
D. L. & W.	..	..	..	40	..	..	..	..	15	..
D. & R. G. W.	..	..	..	..	..	..	15	..	..	20
Erie	..	..	..	40	..	..	..	..	20	..
Ga. Ry.	..	..	..	5	..	..	..	..	..	..
Gr. Tr.	..	..	..	8	..	..	..	..	..	..
T. C.	..	15	..	100	..	25	..	..	..	..
Ind. Union	..	5	..	..	..	..	..	..	..	..
L. & N. E.	..	..	7	..	..	..	..	..	..	..
L.V.	..	..	..	35	..	..	..	..	..	..
L. I.	..	6	..	..	..	..	..	..	..	..
La. & St. L.	..	..	..	..	..	..	..	..	..	15
L. & N.	..	10	..	52	..	..	..	..	8	..
Maine C	..	..	..	..	..	..	..	8	..	..
M. C.	..	10	..	11	..	..	..	..	5	..
M. & W.	..	..	..	5	..	..	..	..	..	..
M., St. P. & S. S. M.	..	..	..	..	..	..	..	..	5	..
M. K. & T.	..	10	..	40	..	..	..	..	5	..
Mo. P.	..	..	..	46	..	..	..	..	..	4
M. & O.	..	..	..	10	..	..	..	..	..	..
N. C. & St. L.	..	..	..	12	..	..	..	..	..	3
N. Y. C.	..	50	..	122	..	..	..	..	30	..
N. Y. C. & St. L.	..	..	..	15	..	..	..	..	4	..
N. Y., N. H. & H.	..	20	..	..	..	..	..	..	..	..
N. & W.	..	..	..	..	..	..	30	..	..	12
N. S.	..	..	5	..	..	..	..	..	..	..
N. P.	..	..	..	25	..	..	4	..	20	..
Nw. Pac.	..	..	..	..	..	..	..	5	..	..
O. W. R. R. & N.	..	..	..	..	..	15	3	..	..	..
P. R. R.	..	..	..	..	100	..	..	..	15	..
P. & P. U.	6	..	..	..	..	..	..	..	..	..
P. M.	..	20	..	..	..	..	..	..	..	..
P. & R.	..	..	25	..	..	..	..	..	5	..
S. L. & S. F.	..	..	..	35	..	..	..	..	..	15
S. P.	..	..	..	..	..	..	..	..	9	..
So. Ry.	..	6	..	15	..	..	..	..	..	..
T. C.	..	..	..	8	..	..	..	..	..	..
T. & P.	8	..	..	..	..	..	..	..	8	..
T., St. L. & W.	..	..	5	..	..	..	..	..	..	..
U. P.	..	..	..	..	..	73	10	..	..	..
W. M.	..	..	10	..	..	..	..	..	..	39
W. P.	..	..	..	6	..	..	..	..	..	..

A large proportion of the orders were placed in the latter part of the year. Largely for this reason the records of locomotives built showed only 1,303 for domestic and 231 for foreign use, a total of 1,534, which is lower than that of any year since 1897. However, in addition to new locomotives the builders handled a large volume of repair work for the railroads which was placed on account of the shopmen's strike.

TABLE III—TYPES OF LOCOMOTIVES ORDERED IN 1922

Type	Railroad	Industrial	Export
0-4-0	2	42	22
0-6-0	74	46	2
0-8-0	214	0	0
0-10-0	1	0	0
2-6-0	4	6	3
2-6-2	4	19	4
2-8-0	73	3	29
2-8-2	1,231	11	46
2-10-0	104	0	0
2-10-2	157	0	0
Mallet	116	0	0
4-4-0	4	0	2
4-4-2	0	0	0
4-6-0	19	0	0
4-6-2	299	0	9
4-8-2	158	0	8
Miscellaneous	7	4	4
Geared	0	19	0
Electric	29	0	14
Total	2,486	150	143

The condition of locomotives on the railroads was at the worst in September, 1922, when 29.9 per cent of the freight locomotives on line were in unserviceable condition. Since then the condition has steadily improved and is now nearly normal.

Freight Car Orders

Freight cars ordered in 1922 for service in the United States and Canada reached a total of 180,900, the largest total reported since 1912, and eight times the 1921 figure.

The freight car buying movement began somewhat earlier in 1922 than did the buying movement for locomotives and was heaviest during the latter part of the year. Important orders were placed by practically every large railroad.

Freight car production for 1922 totaled 66,747 for the United States and Canada and 1,226 for export. The grand total of 67,973 was much lower than the number ordered. The buying in 1921 was abnormally light and but little work was carried over into 1922 while a considerable portion of the orders placed in 1922 will not be delivered until 1923.

TABLE IV—ORDERS FOR FREIGHT CARS SINCE 1915

Year	Domestic	Canadian	Export	Total
1915	109,792	......	18,222	128,014
1916	170,054	......	35,314	205,368
1917	79,367	......	53,191	132,558
1918	114,113	9,657	53,547	177,317
1919	22,062	3,837	3,994	29,893
1920	84,207	12,406	9,056	105,669
1921	23,346	30	4,982	28,358
1922	180,154	746	1,072	181,972

Prior to 1918, Canadian orders included in domestic.

In addition to the construction of new cars the builders handled a considerable volume of repair business in 1922.

Export orders in 1922 totaled only 1,072 and production 1,226. This is a low point which was equalled only twice in the last 25 years, namely in 1914 and 1908. The largest number built for export in any one year was 61,813 in 1919, and the largest number ordered was 53,547 in 1918.

Throughout 1922 the bad order car percentage averaged about 14 per cent. At its worst on August 1 the total number of unserviceable cars was, according to the Car Service Division reports, 345,013 or 15.3 per cent of the total cars

on line. The total has since been substantially reduced; on December 1, the number was 226,288 or 9.9 per cent. The normal percentage should be about 5 or 5.5 per cent.

The types of freight cars ordered in 1922 was shown in Table V. In this connection it will be of interest to refer to Table VI which gives the number of freight cars of various classes which were in service on Class 1 railways on January 1, 1922. A comparison of these tables shows that the

TABLE V—TYPES OF FREIGHT CARS ORDERED IN 1922

Type		Number	Per cent
F	Flat and Logging	3,048	1.7
G	Gondola	36,876	20.4
H	Hopper	34,487	19.1
R	Refrigerator	22,987	12.7
S	Stock and poultry	4,683	2.6
T	Tank	5,485	3.0
V	Ventilated box	1,250	0.7
X	Box	67,337	37.2
	Ballast and dump	980	0.5
	Not classified	2,960	1.6
N	Caboose	807	0.4
	Total	180,900	100

total freight cars ordered during 1922 was 7.7 per cent of the number in service at the beginning of the year. These orders when delivered will materially strengthen the situation especially as regards refrigerator and tank cars.

Of high capacity cars, 140,000 lb., the Baltimore & Ohio ordered 1,000 gondolas, the Denver & Rio Grande Western 700 gondolas, the Norfolk & Western 6,000 hoppers, the Philadelphia & Reading 2,000 hoppers and 1,000 gondolas and the Pittsburgh & Lake Erie 3,000 hoppers and 2,018 gondolas.

The pressing need of new freight train equipment is strikingly brought out by the fact that during the four years of

TABLE VI—FREIGHT CARS IN SERVICE JANUARY 1, 1922, CLASS 1 RAILWAYS

Type	Number	Per cent
Flat	102,839	4.4
Coal	935,061	39.9
Refrigerator	63,855	2.7
Stock	81,677	3.5
Tank	10,106	0.4
Box	1,038,222	44.3
Miscellaneous	83,940	3.6
Caboose	29,087	1.2
Total	2,344,787	100

1918, 1919, 1920 and 1921 only 239,663 new freight cars were installed on Class 1 railways whereas 243,156 cars were retired, a net reduction of 3,493 cars. There was an increase of 9,225 cars in 1918 and an increase of 32,745 cars in 1919, but these slight gains were more than wiped out by a decrease of 39,153 cars in 1920 and a further decrease of 6,310 cars in 1921. A recent report of the Interstate Commerce Commission shows 32,138 fewer freight cars in service in October, 1922, than at the same time a year before.

Passenger Car Orders

Orders for equipment for passenger trains placed in 1922 totaled 2,469 cars for service on railroads in the United States and Canada. This was a considerable improvement

TABLE VII—ORDERS FOR PASSENGER EQUIPMENT CARS SINCE 1916

Year	Domestic	Canadian	Export	Total
1916	2,544	......	109	2,653
1917	1,124	......	43	1,167
1918	109	22	26	157
1919	292	347	143	782
1920	1,781	275	38	2,094
1921	246	91	155	492
1922	2,382	87	19	2,488

Prior to 1918, Canadian orders included in Dcmestic.

over the figures for recent years as will be noted from Table VII. The types of the cars ordered are given in Table VIII. In addition to these cars orders were placed for over 60 gasoline rail-motor cars on 35 railroads. This list, however, is probably not complete. The increasing favor with which this type of equipment is being received in all parts of the country for branch line service is one of the noticeable features of the year.

As was the case with locomotives and freight cars the production of passenger cars in 1922 fell far below the num-

TABLE VIII—TYPES OF PASSENGER EQUIPMENT CARS ORDERED IN 1922

Type	Number
Coach, combination passenger, etc	1,337
Sleeping, parlor, chair, etc	248
Dining	71
Baggage, express, mail	486
Express refrigerator	270
Milk	19
Horse	19
Private, business, miscellaneous	9
Steam and storage battery	4
Total	2,469

bered ordered. During the year the passenger cars built totaled 891 which included 676 for the United States, 71 for Canada and 144 for export.

Shop and Terminal Construction in 1922

ONE class of facilities whose inadequacies were most evident during the heavy traffic of 1917 and again during the recent period of heavy business is that required for the maintenance and repair of locomotives and cars. This need is particularly pressing now because of the accumulation of repair work to be done. Furthermore, there is a growing realization of the necessity for securing more service from locomotives, which calls for the reduction of delays while awaiting repairs. As a result many of the railways have placed appropriations for improvements to these facilities near the top of their budgets.

Among the first projects which the Atchison, Topeka & Santa Fe undertook following federal control was a large erecting shop at Albuquerque, N. M., which was completed during the year and which involved the expenditure of more than $3,000,000. This road has since authorized the construction of other facilities at that point and at San Bernardino, Cal., which are now under way. The Pennsylvania announced recently that it will build two large shops at Altoona, Pa., while it also has extensive improvements of a similar character under way at other points.

Among the roads which will add to their facilities for the repair of cars, the Great Northern will expend $152,000 for buildings at St. Cloud, Minn., and Great Falls, Mont., while the Union Pacific will add to its car shops at Pocatello, Idaho, at a cost of $135,000.

The Union Pacific will spend $1,750,000 at Los Angeles while the Pere Marquette contemplates the expenditure of $1,000,000 at Detroit. The Illinois Central has appropriated $766,000 for additional mechanical facilities at two points, while the Great Northern will spend over $400,000 at St. Cloud, Minn. The Norfolk & Western will spend $500,000 for additional facilities at two points and the Chicago, Rock Island & Pacific $250,000 at one engine terminal.

Other work for which appropriations have been made includes approximately $1,000,000 on the Southern Pacific Lines for additions at Houston, El Paso and Jacksonville, Tex., and LaFayette, La., and $140,000 on the Western Pacific. The Erie will complete its erecting shop now under construction at Hornell, N. Y., and will build a new power house at Jersey City, N. J.

The Chicago, Burlington & Quincy is expending $2,300,000 for new shops at Denver, Col.; the Missouri Kansas & Texas $1,500,000 for a locomotive repair shop at Waco, Tex., and the Western Maryland $400,000 for a locomotive repair shop at Port Covington, Md. Other roads which are

making large additions to their shop facilities are the Louisville & Nashville, the Ulster & Delaware and the Gulf & Ship Island.

In addition to shop improvements new or enlarged engine terminals are being constructed at a number of points.

Closely allied with this is the provision of adequate shop tool equipment, the necessity for which is being realized to an increasing degree in recent years. Among the appropriations for this purpose are $536,000 on the Illinois Central; $500,000 on the Erie; $300,000 on the Norfolk & Western; $194,000 on the New York, Chicago & St. Louis; $150,000 on the Rock Island and a similar amount on the Delaware, Lackawanna & Western; $104,000 on the St. Louis Southwestern; $100,000 on the Pere Marquette; $50,000 on the Denver & Salt Lake and a similar amount on the Great Northern. Other roads which will spend smaller amounts for this purpose include the Ann Arbor ($25,000); the Chicago Great Western ($33,000); the San Antonio & Aransas Pass ($25,000), and the Union Pacific ($30,000).

Water treating facilities have not been overlooked and liberal expenditures for this purpose are contemplated by a number of roads. Among the projects which have been mentioned specifically, the Wheeling & Lake Erie contemplates the construction of a new treating plant.

Partial List of Construction in 1922

Alaskan Railroad.—Roundhouse at Curry (Mile 249); extension of machine shop at Anchorage to double its size; erection of new power house at Anchorage.

Atchison, Topeka & Santa Fe.—New boiler shop at Albuquerque, N. M., cost $400,000.

Atlantic Coast Line.—New 25-stall enginehouse and 100-ft. turntable at Southover, near Savannah, Ga., cost $140,000 (completed).

Baltimore & Ohio.—Engine terminal improvements at Washington, D. C., cost $187,000 (60 per cent completed).

Chicago, Burlington & Quincy.—New shops at Denver, Col., cost $2,300,000 (25 per cent completed).

Cleveland, Cincinnati, Chicago & St. Louis.—New 5-stall engine terminal at Sheff, Ind., cost $200,000 (completed). New 6-stall engine terminal at Ansonia, Ohio, cost $170,000 (completed).

Great Northern.—New engine terminal at Minneapolis Junction, Minn., cost $647,400 (90 per cent completed). Terminal yard and engine facilities at Wenatchee, Wash., cost $1,001,400 (95 per cent completed). New enginehouse, store buildings, tracks, etc., at Skykomish, Wash., to cost $165,900 (80 per cent completed).

Gulf & Ship Island.—New concrete, brick and steel-frame machine shop, enginehouse, boiler shop, blacksmith shop and cinder conveyor, cost $225,000 (75 per cent completed).

Illinois Central.—New yards, shops and engine terminal facilities at Homewood, Ill., cost $8,200,000 (30 per cent completed).

Kansas City Southern.—Improvements to power plant at Pittsburg, Kan., including a 500-kw. direct-connected, engine-driven generator, a 3,000-cu. ft. air compressor, a 350-hp. water-tube boiler and equipment for coal handling, crushing and pulverizing, etc., cost $165,000 (75 per cent completed).

Lake Superior & Ishpeming.—Fireproof building, 500 ft. long, divided into a car repair shop, coach shop and paint shop, at Marquette, Mich., cost $250,000 (5 per cent completed).

Louisiana & Arkansas.—New shops at Minden, La., cost $400,000.

Louisiana Railway & Navigation.—Enginehouse and car repair buildings at Pineville, La., cost $300,000 (20 per cent completed). Enginehouse and machine shops at New Orleans, La., cost $150,000 (10 per cent completed).

Louisville & Nashville.—Yard and mechanical facilities at Loyal, Ky., cost $746,000 (completed). Enginehouse, machine shops and other buildings at Loyal, Ky., cost $464,000 (completed).

Missouri, Kansas & Texas.—Locomotive repair shop at Waco, Tex., cost $1,500,000 (25 per cent completed).

Missouri Pacific.—Installation of boiler washing facilities at various points on system, cost $138,000 (10 per cent completed).

New York Central.—Installation of one 1,500-kw. and one 500-kw. direct-current, turbo-generator at 50th street service plant, New York City, cost $122,000 (90 per cent completed). Remote control sub-station at 110th street, New York City, cost $265,000 (80 per cent completed). Installation of 20,000-kw. turbo-generator at Port Morris, N. Y., cost $881,500 (80 per cent completed). New coal trestle at Belle Isle, N. Y., cost $168,000 (89 per cent completed).

Northern Pacific Terminal of Oregon.—New 1,200,000-cu. yd. hydraulic fill, 8-stall brick and tile enginehouse, cinder pit, turntable, water station, oil fuel station and various other buildings constructed at Guild's Lake freight yard, cost $400,000 (completed).

Oregon Short Line.—Additions to storehouse and changes in present buildings at Pocatello, Ida., cost $153,000 (10 per cent completed). Extension to steel car shop at Pocatello, cost $130,000 (90 per cent completed). Installing 15-ton, 85-ft. span traveling crane in store yard at Pocatello, cost $100,000 (90 per cent completed).

Pittsburgh & West Virginia.—New classification yard and reinforced coaling station, etc., at Avella, Pa., cost $25,000 (completed).

Southern Pacific.—Machine shop at El Paso, Tex., enlarged, cost $240,700 (completed). Engine terminal improvements at various points on the system.

Ulster & Delaware.—Extending present locomotive erecting shop, building new boiler house, installing electric crane and providing other new equipment at Kingston, N. Y., cost $150,000 (60 per cent completed).

Union Pacific.—Coaling station at Carter, Wyo., cost $111,028 (35 per cent completed).

Virginian.—Five-stall extension of enginehouse and alterations to old house at Elmore, W. Va., cost $129,000 (completed).

Western Maryland.—Locomotive repair shop, 100 ft. by 300 ft., at Port Covington, Md., cost $400,000 (completed).

On the State Railways in Jugo-Slavia

Francis J. Cole

FRANCIS J. COLE, who was until recently chief consulting engineer of the American Locomotive Company, died on January 11, at his winter home in California. By Mr. Cole's death the railway field lost a man who was generally recognized as one of the leading locomotive designers of his day. From his eighteenth birthday when he became an apprentice machinist in the Mount Royal shops of the Northern Central Railroad, Baltimore, Md., until his retirement approximately one year ago, his whole life was devoted to this field.

Mr. Cole was the son of an English Episcopal clergyman, who came to the United States and settled on a farm in Virginia, Francis being a young boy at the time. Farm life, however, did not appeal to him and he became an apprentice machinist as noted above. After serving his time, he accepted a position as draftsman under William H. Harrison on the Baltimore & Ohio, at Newark, Ohio. Being young, ambitious and continually seeking advancement he shortly left the Baltimore & Ohio to become a draftsman on the West Shore, at Frankfort, N. Y., under R. H. Soule, superintendent of motive power. John Player, Mr. Cole's immediate superior, was the mechanical engineer. Also it was here that Mr. Cole became associated with J. E. Sague, who was one of the other draftsmen and with W. F. Dixon, who was a special apprentice.

Francis J. Cole

The impression of his usefulness that he had left with the B. & O. at Newark was such that after a short time of employment at Frankfort, he was offered the position as chief draftsman of the B. & O. at Newark, Ohio. Here he further established his ability, resulting in his transfer to the Mount Clare shops as chief draftsman. Later, about 1890, when G. B. Hazlehurst became general superintendent of motive power, Mr. Cole was appointed mechanical engineer in charge of the design of all mechanical equipment, including cars and locomotives. His exceedingly efficient work in standardizing the design of both the locomotives and cars on this road attracted national attention. Also while on the B. & O. he published a series of articles on locomotive design, which were widely used and generally recognized as the best data available.

In the course of time Mr. Dixon, who had been an apprentice on the West Shore during Mr. Cole's short employment with that road, had become mechanical engineer of the Rogers Locomotive Works at Paterson, N. J. In the fall of 1895, when Mr. Dixon accepted an offer to go to Russia to build a locomotive works, he recommended to Reuben Wells that Mr. Cole succeed him and in 1896 Mr. Cole became mechanical engineer of the Rogers Locomotive Works.

The Rogers Works was temporarily closed in 1899. During this time Mr. Cole accepted under Mr. Sague the position of assistant mechanical engineer of the Schenectady Locomotive Works.

Later when the American Locomotive Company was formed, Mr. Sague becoming mechanical engineer, immediately appointed Mr. Cole as his assistant, and later when Mr. Sague became assistant vice-president, he appointed Mr. Cole as mechanical engineer of the company. This position was held by Mr. Cole until later in life, when wishing to be relieved of some of the arduous duties, he was appointed chief consulting engineer. This position he retained until his recent retirement.

Mr. Cole was a quiet unassuming man, who never spoke of himself or what he did. He had a vein of persistence which generally led to getting his own way, reinforced by the fact that his own way was generally right. He was a close and thorough student with an inborn determination to arrive at exact facts in all his investigations; all resulting in his becoming internationally known as an eminent authority on the mechanical design and performance of the steam locomotive. His name is written high in the annals of American locomotive building.

His best known work was during his connection with the American Locomotive Company, when he was a leading factor in standardizing the locomotive designs and methods of the different plants which were organized under one management to form this corporation.

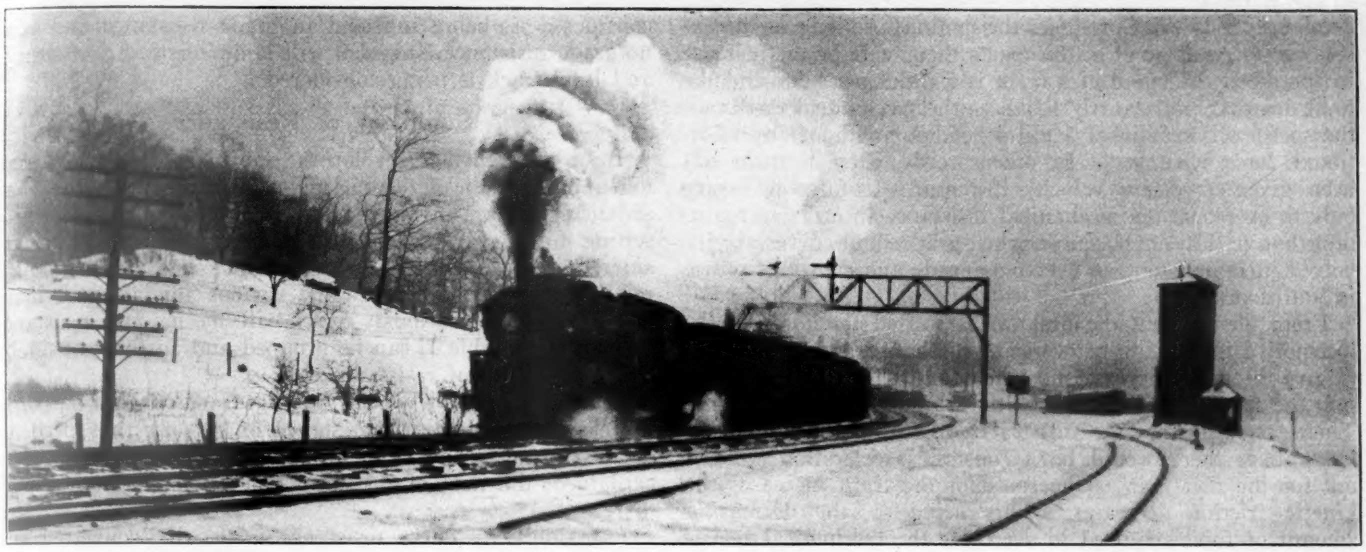
In the adoption of the superheater Mr. Cole took a prominent part. His work on boiler ratios was a radical departure from former methods and today are universally used. He also will be remembered for his four cylinder compound of former days; and more recently as the designer of Number 50,000, the Cole trailing truck and an innumerable number of details all tending toward refinement of design. He was a bold designer, though a safe one and could never be accused of fostering anything in the way of freakish construction.

He was a prominent member of the American Society of Mechanical Engineers, the American Railway Association, the American Society of Testing Materials and many others.

About two years ago he built a winter home in Pasadena, Cal., and within the past year retired from active business. For the past four weeks he had not been feeling at his best though not thought to be seriously ill. However, after four days of more serious illness he passed away in his sleep at his winter home in Pasadena.

He was a devoted husband, a true and loyal friend to those who were fortunate enough to know him intimately, and of a character whose life and example are only for the good.

LUMBER MILLS OF BRITISH COLUMBIA report that 90 per cent of their output is now being purchased by China and Japan. The Prairie Provinces were formerly the chief outlet for this province's lumber. So insistent is the demand from the Orient that most of the Coast mills are said to be sold out a month ahead.



Freight Train Resistance and Tonnage Ratings

Part I

Method of Determining Adjustment Factor and Applying It Under Various Operating Conditions

By Richard J. McCarty, Jr.
Division Superintendent, Delaware & Hudson

FOR many years after railroads came into existence they were run by empirical methods alone, which, although not scientific, produced the desired results. Continued experience, however, brought out the fact that certain relations exist between various features of train resistance which could be used to increase the efficiency of the locomotives, and as competition increased and the necessity for cheaper operation became more important, these relations were further developed and applied with the result that certain laws governing the movement of trains were established. The purpose of this article is to explain these laws and show how their application results in more economical train operation.

Elements of Train Resistance

In order to start a train, a locomotive must exert a drawbar pull of sufficient force to overcome the total resistance of the train to motion, an analysis of which is given in Table I:

TABLE 1

A—Mechanical Resistance,
- (1)—Static Friction (Friction of rest.)
  - (a) Journal friction.
  - (b) Flange friction (Except on curves.)
  - (c) Air friction.
  - (d) Other sliding friction.
  - (e) Rolling friction.
- (2)—Kinetic Friction (Friction of Motion.)
  - (a) Journal friction.
  - (b) Flange friction (Except on curves.)
  - (c) Air friction.
  - (d) Other sliding friction.
  - (e) Rolling friction.

B—Resistance due to acceleration.
C—Resistance due to grades.
D—Resistance due to curves.

Of the different elements of mechanical resistance, journal friction is by far the most important; so much so that all other items put together make only a small part of the total. Therefore in the further handling of the subject it will be unnecessary to consider separately the component items of mechanical resistance.

The static friction of any given car or train is considerably greater than the kinetic friction and kinetic friction is greatest at the instant motion takes place, but decreases rapidly as the speed increases up to a point between five and ten miles per hour depending upon conditions, after which kinetic friction increases as the speed increases. For this reason the resistance of a car to motion is greater than the resistance of the car to continued motion after having been started, from which it is clear that unless some means were adopted to overcome the greater resistance of static friction as compared to kinetic friction, a locomotive would be unable to start a full tonnage train which otherwise it could successfully handle. This is done in railroad practice by the provision of slack in the draft gears of the cars which enables a locomotive to start a train, one car at a time.

Static friction being restricted to one car at a time by the operation of the slack, it become a very small proportion of the total static and kinetic friction, and as the number of cars set in motion increases, the proportion of static friction decreases. Also the slack permits of a comparatively quick acceleration, one car at a time, which greatly overcomes the high resistance of kinetic friction at extremely slow speeds. Therefore, it is proper to continue the discussion without further regard to static friction and also without regard to the values of kinetic friction at speeds below that resulting from the operation of the slack.

Acceleration

A certain amount of force is required to give a train motion and the excess force over that required to overcome the mechanical resistance of the train, which is the force of

acceleration, is what produces the motion. As long as the excess, or force of acceleration exists there will be an increase in speed. If the speed of a train is 5 miles per hour and the total drawbar pull exactly balances the mechanical resistance the speed will remain at 5 miles per hour without any additional force whatever. In other words, after a train has been given a certain velocity it requires a force necessary only to overcome the mechanical resistance in order to maintain that velocity. Of course, when grades and curves are involved, it is necessary to overcome grade and curve resistance in addition.

From the moment the first car is started the force of the locomotive is working to overcome mechanical resistance and to give the train motion, and when the last car is set in motion the force required to move the train is at the maximum. Then assuming that the full tractive force of the locomotive is applied, there would be a constant acceleration were it not for the fact that as the speed of the train increases the kinetic friction decreases. This being so, the decreasing amount of force required to overcome the mechanical resistance results in an increasing amount of force available for acceleration, and therefore the train acquires speed with an increasing acceleration until the speed of minimum friction is reached.

Before any values can be given for acceleration it is necessary to know in what distance or in how much time the desired speed should be acquired. Operating conditions have a great deal to do with this, and on that account it is hardly possible to establish a standard value. In this connection, however, it is important to bear in mind the fact that in actual practice that part of the tractive force overcoming mechanical resistance decreases as the speed increases from extremely slow speeds up to the speed of minimum friction, while that part of the tractive force producing acceleration increases the second proposition resulting from the first and, also as the piston speed increases beyond its speed of maximum effectiveness the total drawbar pull decreases. Therefore, except in cases where unusually quick starts are required, it is not necessary to further consider this item with respect to specific values, in working out a tonnage rating formula.

Grade and Curve Resistance

Resistance of grades is the result of gravity which is the force that must be overcome when a body is lifted. When a car or train moves up-grade it is being lifted, and the amount of force required depends on the rate of grade. This is the problem of the inclined plane in which the sustaining force is to the weight as the height of the plane is to the length, or specifically stated, the resistance of grades is overcome at the rate of 20 lb. per ton for each one percent of grade.

Resistance of curves is very difficult to determine and it varies with the degree of curvature, length of curve, elevation of outer rail and kind of equipment. All figures for curve resistance do not agree but the average value, which is much used, is 1.4 lb. per ton for each degree of curve for steam locomotive and 0.8 lb. per ton for each degree of curve for freight cars. It is frequently the practice to disregard light degrees of curvature, which practice under ordinary conditions can be followed out for curves under two degrees. Also when curvature is compensated, curve resistance may be disregarded altogether.

If any curve over two degrees is as long or longer than any full tonnage train the resistance of 0.8 lb. per ton should apply to the entire train, but if not, the resistance of 0.8 lb. per ton should apply to only that part of the train that is on the curve.

In computing ratings, it is frequently the practice to convert the curve resistance in pounds per ton into the equivalent grade and add the equivalent to the actual grade. In the further handling of this subject curve resistance will be considered as being included in grade resistance and when no grade resistance is used it will be understood that straight and level track is being considered.

Summary of Resistances

In order to further develop the subject it will be necessary to summarize the foregoing description of the various resistances that are involved in train operation with a view of setting forth only such items as need be specifically considered in developing various formulas and explaining the relations that exist between the various fundamental items.

For reasons, previously given, all mechanical resistance, as shown in Table I, can be grouped and further considered as a single unit of resistance.

On account of the operation of the slack and the rapid decrease of mechanical resistance of cars as the speed increases up to the speed of minimum friction, which has been explained, the item of resistance due to acceleration can be disregarded.

For simplicity curve resistance is usually converted into equivalent grade resistance and considered as a part of the grade resistance.

Therefore, all further consideration of the subject may be properly based on only two items of resistance as follows: (1) Mechanical resistance, (2) Grade resistance.

Locomotive Resistance

Obviously the first step in determining the pulling capacity of a locomotive is to ascertain how much of the power is used within itself before any drawbar pull is obtained. In any train the total resistance of both locomotive and cars is overcome by the cylinder tractive force of the locomotive. For analytical purposes this force will be represented by formula as follows:

Cylinder tractive force $= F = f' + LG + f$ .... (1)

in which f' = Total mechanical resistance.
L = Total weight of engine and tender in tons.
G = Grade resistance in lb. per ton.
f = Balance available for drawbar pull.

The mechanical resistance of steam locomotives is generally taken as 25 lb. per ton for the weight on the drivers and for the engine trucks the same rate in pounds per ton as a car of the same axle load. Mechanical resistance of tenders should be computed loaded at the rate in pounds per ton given for a car of the same weight.

When high speeds are involved it is necessary to make special allowance for head-end air resistance but as this item in ordinary freight service is of no practical importance it may be dropped in the further consideration of this particular subject.

Grade resistance is the same as for car resistance previously explained but in adding curve resistance special values pertaining to the resistance of locomotives on curves must be used as shown under the heading "Resistance of Curves."

From equation (1), $f = F - f' - LG$. .... (2)

This equation may be developed into a formula of practical value in connection with any given class of locomotive so that the drawbar pull on any grade may be easily derived. For example, the E 57 class of 2-8-0 type locomotives of the Delaware & Hudson have the following specifications:

Cylinder tractive force at 250 ft. per min. piston speed	56,900 lb.
Diameter of drivers	57 in.
Stroke	30 in.
Weight on front truck	12.75 tons
Weight on drivers	118.18 tons
Weight on trailing trucks	......
Weight of tender in service	69.63 tons
Total weight	200.56 tons

Cylinder tractive force of locomotives is generally based on a piston speed of 250 ft. per minute and therefore if the train speed required on any ruling grade results in a piston speed of more than 250 ft. per minute, a reduction in the tractive force takes place which can be easily adjusted by applying the proper speed factor to the conditions under

consideration. Speed factors in tabulated form are published in various books pertaining to locomotive construction and operation.

It will be assumed that the desired train speed is 10 miles per hour, which gives a piston speed of 295 ft. per minute. The speed factor at this piston speed is 0.954 which applied to the cylinder tractive force of 56,900 lb. gives 54,283 lb. available at 10 miles per hour. Therefore, this locomotive on straight and level track at 10 miles per hour would have the following cylinder tractive force and mechanical resistance:

Cylinder tractive force	54,283 lb.
Resistance—	
Front truck at 3.7 lb. per ton	47 lb.
Drivers at 25 lb. per ton	2,955 lb.
Trailing truck	.....
Tender at 3.1 lb. per ton	216 lb.
Total resistance	3,218 lb.

Then by substitution, equation (2) should read

$$f = 54{,}283 - 3{,}218 - 200.56\,G \qquad (3)$$

$$\text{or } f = 200.56\,(254.6 - G) \qquad (4)$$

By substituting the grade resistance in pounds per ton for any given grade in place of G, the drawbar pull for the class of locomotive in question is easily found. When this is done it is then necessary to determine the proper tonnage rating for that amount of drawbar pull, from which the ratings for other classes of locomotives can readily be found by multiplying that rating by a value that represents the ratio of the cylinder tractive force of any other given class of locomotive to the cylinder tractive force of the class of locomotive selected as a basis. In this way it is necessary to make detail calculations for only one class of locomotive on any given district to find all the other ratings. This brings up the question of car and train resistance which will now be explained.

Car and Train Resistance

The first element to consider in this connection is "Mechanical Resistance."

Master Mechanic's Proceedings of 1914 gives the mechanical resistance of freight cars at 5 miles per hour as shown in Table II.

TABLE II

Mechanical Resistance of Freight Cars at 5 Miles per Hour

Wt. of cars and contents		Mech. resist. per ton		Mech. resist. per car	
Tons	Per cent Incr.	lb.	Per cent Decr.	lb.	Per cent Incr.
20	Basis	6.8	Basis	136	Basis
25	25	6.0	11.7	150	10.3
30	50	5.4	20.6	162	19.1
35	75	4.8	29.4	168	23.5
40	100	4.4	35.2	176	29.4
45	125	4.0	41.2	180	32.3
50	150	3.7	45.6	185	36.0
55	175	3.5	48.5	193.5	42.3
60	200	3.3	51.5	198	45.6
65	225	3.2	52.9	208	52.9
70	250	3.1	54.4	217	59.5

From Table II, the following corollaries may be deducted:

1—The mechanical resistance of cars in pounds per ton decreases when the weight increases, but in less proportion.

2—The mechanical resistance of cars in pounds per car increases when the weight increases, but in less proportion.

Therefore, from 1 and 2.

3—The number of actual tons a given drawbar pull can move will increase when the average weight of the cars increases, while the number of cars will decrease.

These facts are of the greatest importance as will be seen in their application to practical purposes.

If the mechanical resistance of all cars in pounds per ton were the same, in order to find a tonnage rating for any given tractive force it would be necessary only to divide the available drawbar pull by the total of the following items of resistance in pounds per ton.

(1) Mechanical Resistance.

(2) Grade Resistance (Including curve resistance).

But in view of the fact that at any given speed the mechanical resistance of cars of different weights are not in proportion to their weight, tonnage ratings worked out by this method alone will not produce a constant amount of total resistance for each rating regardless of car weights. Therefore, it is clear that actual tonnage ratings must be arranged so that any train of a certain rating will have the same total resistance as any other train of the same rating, regardless of whether the cars making up the trains are light weight cars or heavy weight cars. There are several ways of doing this but the principle is the same in all cases. The adjusted tonnage method, being extensively used, will be taken as a basis in further developing the subject.

Adjusted Tonnage Method

In this method there is taken as a basis a given amount of drawbar pull, from which is found, either by test or calculation, the tons and cars of light cars and the tons and cars of heavy cars that can be handled over any given district. These amounts are then equated, from which a rating is obtained that will produce approximately the same amount of total resistance regardless of car weights.

The values of mechanical resistance as used hereafter are all based on those given in Table II. Tables III and IV give a comparison of two trains of the same total resistance but of unequal weight.

TABLE III

Two Trains of Same Total Resistance but of Unequal Weight
Straight and level track—Speed 5 miles per hour.

Items Resistance in lb.	Lighter Car Train	Heavier Car Train	Difference
Tons per car	20	60	40
Mech. resist. per ton	6.8	3.3	—3.5
Grade resist. per ton	..	..	..
Mech. resist. per car	136	198	62
Grade resist. per car	..	..	..
Actual tons	1,980	4,080	2,100
No. of cars	99	68	—31
Total mech. resist.	13,464	13,464	.....
Total grade resist.	..	..	..
Total all resist	13,464	13,464	.....
The above trains on Adjusted Tonnage Rating Basis:			
Adjustment	67.74	67.74	.....
Actual tons	1,980	4,080	+2,100
Potential tons	6,706	4,606	—2,100
Adjusted tons	8,686	8,686	.....

TABLE IV

Two Trains of Same Total Resistance but of Unequal Weight
Grade 1 per cent—Speed 5 miles per hour.

Items Resistance in lb.	Lighter Car Train	Heavier Car Train	Difference
Tons per car	20	60	40
Mech. resist. per ton	6.8	3.3	—3.5
Grade resist. per ton	20.0	20.0	...
Mech. resist. per car	136	198	62
Grade resist. per car	400	1,200	800
Actual tons	502.4	577.9	75.5
No. of cars	25.12	9.63	—15.49
Total mech. resist.	3,416	1,907	—1,509
Total grade resist.	10,048	11,557	+1,509
Total all resist.	13,464	13,464	.....
The above trains on Adjusted Tonnage Rating Basis:			
Adjustment	4.87	4.87	.....
Actual tons	502.4	577.9	75.5
Potential tons	122.3	46.8	75.5
Adjusted tons	624.7	624.7	.....

From these two tables it will be seen that regardless of conditions, a given drawbar pull will move more tons and less cars of heavier cars than of lighter cars.

In order to make an analysis of general application the values given in Table IV will be converted into algebraic expressions as shown in Table V.

TABLE V

Algebraic Expressions for the Values of Table IV
Applicable to straight and level track or any grade

Items	Lighter Car Train	Heavier Car Train	Difference
Tons per car—incl. load	W	(W+w)	w
Mech. Res. in lb. per ton	E	(E—e)	e
Grade Res. in lb. per ton	G	G	..
Mech. Res. in lb. per car	R	(R+r)	r
Grade Res. in lb. per car	D	(D+d)	d
Actual tons	T	(T+t)	t
No. of cars	C	(C—c)	c
Total Mech. Resistance	TE	(T+t) (E—e)	tG
Total Grade Resistance	TG	(T+t) G	tG
Total All Resistance	f	f	..

Although this table is based on the specific values as given in Table IV the formulas that are developed below are true for any other values that might be substituted provided that the total resistances of the trains are equal, and provided that the mechanical resistance in pounds per ton of a heavier car is less than that of a lighter car but not as much less as it would be if it were inversely in proportion to their weights.

From Table V the following fundamental equations are obtained:

LIGHTER WEIGHT CARS:

$$T = CW \quad \dots\dots (5)$$
$$f = T\,(E + G) \quad \dots\dots (6)$$
$$= C\,(R + D) \quad \dots\dots (7)$$
$$= CW\,(E + G) \quad \dots\dots (8)$$

HEAVIER WEIGHT CARS:

$$(T + t) = (C - c)\;(W + w) \quad \dots\dots (9)$$
$$f = (T + t)\;(E - e + G) \quad \dots\dots (10)$$
$$= (C - c)\;(R + r + D + d) \quad \dots\dots (11)$$
$$= (C - c)\;(W + w)\;(E - e + G) \quad \dots\dots (12)$$

The fundamental equations give in cars and car weights a comparison of the tons of a lighter car train and a heavier car train respectively, as follows:

Lighter car train = CW .... From (5)
Heavier car train = (C — c) (W + w) .... From (9)

Equating these two ratings which are equal in total resistance but unequal in tons.

$$CW + t = (C - c)\;(W + w) \quad \dots\dots 13)$$

in which (t) represents the difference in tons of the two trains. In order to express these ratings in the same terms it is necessary to find an amount in tons that added to each car weight will equalize the difference in mechanical resistance that caused the difference in the tons of the two trains.

Let (x) represent the amount required.

Then from (5) and (9) $C(W + x) = (C - c)\;(W + w + x) \quad \dots\dots (14)$

From which $$x = \frac{t}{c} \quad \dots\dots (15)$$

Therefore, from (14) and (15)

$$C(W + \frac{t}{c}) = (C - c)\;(W + w + \frac{t}{c}) \quad \dots\dots (16)$$

$$T + C\frac{t}{c} = (T + t) + (C - c)\frac{t}{c} \quad \dots\dots (17)$$

in which

$$T \text{ and } (T + t) = \text{Actual tons} \quad \dots\dots (18)$$
$$\frac{t}{c} = \text{Adjustment} \quad \dots\dots (19)$$
$$C\frac{t}{c} \text{ and } (C - c)\frac{t}{c} = \text{Potential tons} \quad \dots\dots (20)$$
$$C(W + \frac{t}{c}) \text{ and } (C - c)\;(W + w + \frac{t}{c}) = \text{Adj. tons} \quad \dots\dots (21)$$

Equations (14) and (15) mean that if there is added to the weight of each car of each train an amount of tons equal to the difference in the tons of the two trains divided by the difference in the cars, the sum of the car weights plus the adjustments of one train will equal the sum of the car weights plus the adjustments of the other train. This amount is the adjusted rating and it will produce trains of the same mechanical resistance regardless of car weights within certain limits which will be taken up in proper order.

By using in equations (16) and (17) the values given in Table IV the following is obtained:

From (16) $25.12 \times (20 + 4.87) = 9.63 \times (60 + 4.87) \quad \dots\dots (22)$
From (17) $502.4 + (25.12 \times 4.87) = 577.9 + (9.63 \times 4.87) \quad \dots\dots (23)$
or for both (16) and (17) $624.7 = 624.7$

Although the two trains in question are of different weight, the adjusted ratings, as will be seen, are the same for both.

Tables III and IV indicate that in any two trains of the same adjusted tonnage rating, the difference in actual tons is always equal to the difference in the potential tons. That this is true in all cases, may be shown as follows:

From (16) $$CW + C\frac{t}{c} = (C - c)\;(W + w) + (C - c)\frac{t}{c} \quad \dots\dots (24)$$

Then $$(C - c)\;(W + w) - CW = C\frac{t}{c} - (C - c)\frac{t}{c} \quad \dots\dots (25)$$

From which $$t = t \quad \dots\dots (26)$$

The principle of an adjusted tonnage rating is, that as the number of cars increase the number of adjustments or the potential tons increase, and as the potential tons increase, the actual tons decrease. Therefore, the function of the adjustment is to balance the tons, the number of cars and the total resistance.

(To be continued)

Two-Cylinder Pacific Type Locomotive for the Midi Railroad of France

The Chemins de Fer du Midi has recently placed in service 20 two-cylinder, superheated, 4-6-2 type locomotives built by the Societe Alsacienne de Constructions Mechanique, Belfort, France. Locomotives formerly used were of approximately the same weight and capacity, but of the four-cylinder compound type. A change was made to the two-cylinder, single-expansion, superheated type because of greater simplicity and lower cost of maintenance, tests having shown that the efficiency would be practically the same. The boiler was changed from the Belpaire to the straight top type, the number of 5¼-in. flues with superheater elements increased from 24 to 28 and the number of 2¼-in. tubes decreased from 145 to 123. The evaporative heating surface and grate area remained practically the same, but the volume of gas passed through the large flues was increased from 40 per cent to 47 per cent, with about a 20 per cent increase in superheating surfaces. The boiler pressure was dropped from 227 lb. to 185 lb. The new locomotives weight 196,420 lb. in working order, with 118,720 lb. on the drivers, and have a rated tractive force of 32,900 lb. The cylinders are 25 in. by 25⅝ in. and the driving wheels are of 76⅜ in. diameter. The evaporative heating surface is 2,179 sq. ft., the superheated surface 791 sq. ft., and the grate area 43 sq. ft. These locomotives are hauling express trains having an average weight of 254 tons with an average coal consumption of 47 lb. per mile.

The Design of Engine and Tender Drawbars

Some Comments on the Existing Practice with Suggestions for a More Logical Basis of Design

By H. J. Coventry

IN view of the fact that the safety of life and property depends so largely upon avoiding failure of the drawbar between engine and tender, it is rather surprising to find so little definite and no unanimous opinion as to the basis of design, or any agreement as to a proper allowable stress on the material.

That drawbars do break sometimes and with fatal results is sufficient warrant for further inquiry as to whether our fundamentals of design are on correct lines, more especially in view of the large and steadily rising tractive force of present day power.

A report on Drawbar and Safety Connections to the American Railway Master Mechanics' Association in 1903 appears to be the first step taken to obtain uniformity of design. The recommendation is made that the area of cross section of the bar body should be a value in square inches, found by dividing the tractive force by a factor (stress) sufficiently low to give a factor of safety that would cover all possible conditions. That is

$$A \text{ sq. in.} = \frac{T}{f}$$

The value of f was to be taken at 4,000 lb. per sq. in. maximum, and the material to be hammered wrought iron, of 45,000 lb. per sq. in. ultimate tenacity. Later we find 4,500 lb. per sq. in. recommended as the factor, and this is confirmed in the report to the A. R. A., Section III, 1920, on this subject. From the variance of discussion on the report at the time of presentation it would appear that opinion was not emphatic or unanimous. A recent inquiry

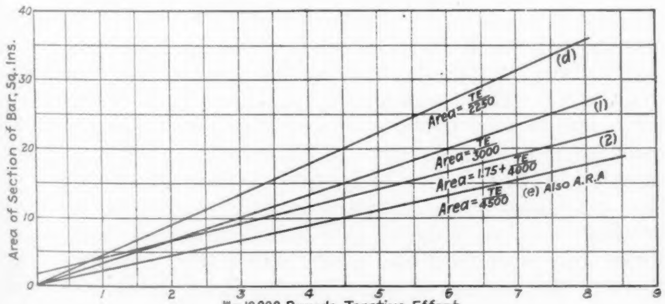


Fig. 1—Graphical Comparison of Drawbar Formulas

among prominent railroads as to their practice for drawbar design, and any formula used elicited the following replies:

Railroad a—No formula, go by precedent.

Railroad b—No formula.

Railroad c—No formula.

Railroad d—Formula $A = \frac{T}{2,250}$ Material—Iron of 45,000 lb. per sq. in.

Railroad e—Formula $A = \frac{T}{4,500}$ Material—Steel of 80,000 lb. per sq. in.

Locomotive builder 1—Formula $A = \frac{T}{3,000}$ or $A = \frac{\text{Total weight}}{18,000}$

Locomotive builder 2—Gave standard dimensions, no formula.

The formulæ given and one to approximate the practice of locomotive builder 2 are shown plotted in Fig. 1. It will be readily seen that to meet a tractive force of 70,000 lb., the minimum would be 15.5 sq. in. and the maximum 31.25 sq. in. in the body of the bar, while if the locomotive happened to be very heavy for its tractive force, an even greater area of bar would be called for as the larger value of the two equations under heading 1 is intended to be used. This wide range, and the absence in many cases of any definite method seems to indicate the need for a better and more logical basis of design.

The following is, therefore, suggested as an improvement, although the impossibility of deriving a complete theory to fit the complicated stresses to which a drawbar is subjected, and at the same time covering the unknown influence of the surrounding structure, is fully recognized.

It is assumed that the amount of slotting in the eye ends, draw pin arrangement, striking casting, etc., are such that the bar never has a compressive load put upon it. Such a condition should be, and can be avoided by proper design of the draft arrangement between engine and tender. Sufficient clearance should also be provided in the draw pin pocket to void the possibility of putting side bending stresses in the bar when the locomotive passes round the sharpest curve, or oscillates at high speed.

The practice of offsetting should not be tolerated owing to the rapid increase of stress for even small offsets for a given cross-sectional area. Also the tractive force transmitted by an offset bar is less than that delivered to it by the engine draw pin, the balance tending to lift or depress the tender according to whether the engine pin is higher or lower than the tender pin.

The amount of slotting in the eye should not be more than is absolutely necessary for the conditions, and the holes need not be more than 3/16 in. wider than the diameter of the pins.

If these conditions are complied with it can safely be said that the stresses induced in the bar are purely tensile, but of somewhat wide range. From the nature of the case it seems reasonable that the stress would range from that produced by twice the tractive force, seeing that the load is a live one, to anything above, according to the degree of shock. The degree of shock is proportional to the total amount of slotting or slack in the eyes. While the actual amount of slack between the engine and tender is sometimes maintained at a minimum by wedge devices, there is no guarantee that at some time the whole of the slotting will not come into play. For design purposes, therefore, the maximum amount must be considered, and it is conceivable that the tractive force could be applied when the engine and tender are fully compressed. Put in another way, the drawbar is analogous to a bar having a load equal to the tractive force dropped on it from a height equal to the amount of slack.

Work is therefore done on the bar by an amount equal to the product of tractive force and slack, plus the extension of the material; that is,

$$K = T_e (d + x) \qquad (1)$$

Where K = work in inch lb.
T_e = tractive force in lb.
d = total slotting or slack in inches
x = extension of material in inches.

This amount of work is absorbed by the material of the

bar if the connections and surrounding structure are infinitely rigid. The work done by the material is:

$$\frac{1}{2}\,Wx$$

Where W = an equivalent static or dead load
x = extension caused by W
We now have the equation

$$T\,(d + x) = \frac{1}{2}\,Wx \quad \ldots\ldots (2)$$

From definition of modulus of elasticity

$$E = \frac{W}{A} \times \frac{l}{x} \quad \ldots\ldots (3)$$

Where E = modulus of elasticity of the material in lb.
A = area of section in square inches
l = length of section in inches
x, W and d as before
From equation (3)

$$W = \frac{EAx}{l} \quad \ldots\ldots (4)$$

Substituting the value of W in equation (2)

$$T\,(d + x) = \frac{1}{2}\,\frac{EAx}{l}\,x$$

$$T\,(d + x) = \frac{EAx^2}{2l} \quad \ldots\ldots (5)$$

From which for any particular values of T, l, d, A and E the extension x can easily be computed. Having found x the stress f may be found from equation (3) modified:

$$f = \frac{Ex}{l} \quad \ldots\ldots (6)$$

as also $x = \frac{fl}{E}$ substituting this in equation (5)

We obtain $T\,(d + x) = \frac{EAf^2l^2}{2lE^2}$ and

$$T\,(d + x) = \frac{f^2}{2E} \times Al \quad \ldots\ldots (7)$$

Al is obviously the volume of the bar and $\frac{f^2}{2E}$ is the resilience per unit volume if f is taken at the elastic limit.

It is now evident that a drawbar can be made stronger either by increasing the length or volume or using a material of higher resilience and reducing the amount of slotting or slack. Any or all of these methods will have a strengthening influence.

The specification for drawbar material should include a resilience requirement or work done per cubic inch in stretching the bar up to the elastic limit and also work per cubic inch required to fracture a specimen. These two values give a better idea of the suitability of material subjected to shock than ultimate tenacity.

Then equation (7) becomes

$$T\,(d + x) = R \times V \quad \ldots\ldots (8)$$

where R = resilience in inch lb. per cubic inch
V = volume of the bar in cubic inches

As x will be small compared to d, it may be omitted.

Up to this point the assumption has been that the connections of the bar and surrounding structure are infinitely rigid. This, of course, is not true in practice, as all the surrounding material is elastic and absorbs some of the energy of impact. We may, therefore, quite safely select a higher resilience value than that at the elastic limit for the material without actually reaching dangerous high stresses, for it will most probably be found that f, the stress calculated from equation (7), will be abnormally high for any selected average drawbar. It, therefore, becomes a question as to the economical practical value to be assigned to R.

From the experiments of Wohler, Spangenberg and others on fatigue of metals under repeated stresses, it was found that the stress could be much above the elastic limit, if load was applied momentarily and that the limit of stress depended more upon the ultimate static breaking stress, than the elastic limit. Upon these results the "dynamic theory" is based which assumes that a piece of material will not break under repeated loadings if the momentary stress due to sudden application of load does not exceed the statical breaking strength of the material.

Supposing a material of 55,000 lb. per sq. in. tenacity is used. Taking, say 0.94 of this gives 52,000 lb. sq. in. as momentary stress. Equation (7) then becomes

$$52{,}000 = \sqrt{\frac{2E\,Td}{V}}$$

$$\text{If } E = 27{,}000{,}000, \text{ then } V = \frac{27\,Td}{26 \times 52} \text{ or } = \frac{Td}{50} \quad \ldots\ldots (9)$$

The volume of the drawbar V should be taken from center to center of eyes.

A bar designed to this formula would never be stresssd to the breaking point even if the connections were infinitely rigid; the elasticity of the latter provides what is equivalent to a factor of safety. Moreover, a set of bars suitable for different conditions would be all equally strong, under their respective conditions, and it is considered that this method overcomes the objection sometimes raised that the stress of 4,500 lb. sq. in. taken in A. R. A. formula is too low for high tractive forces.

The comparative table of actual existing drawbars and the proposed cross-section as found by equation (9) is of interest in showing the wide difference of bars even when considered on an area-stress-tractive force basis. For example, compare B and C with J. The tractive force is for J 1.7 times B, yet the existing bars have some cross-sectional area. On a volumetric basis they show a little better. The column to the extreme right shows the volume as calculated to formula (9). This table is graphically represented by Fig. 2, in which curve A shows the volumes of bars calculated to the proposed formula, and curve B shows existing bars, all reduced to a standard of one inch slack. From the considerations given above the importance of limiting the amount of wear in eyes is apparent, and bars that have reached the limit of wear that was allowed for in the new bar should be taken out of service.

The eyes should be machined accurately to dimensions, and the body of the bar should be as smooth and of as even section throughout as possible in order to avoid localization of stress.

COMPARATIVE TABLE OF DRAWBARS

Drawbar	Tractive effort, in lbs.	Existing Drawbars: Slack, in.	Section	Area, sq. in.	Length, in.	Volume, cu. in.	Proposed: Section	Area, sq. in.	Volume, cu. in.
A	24,573	1⅝	5 in. by 3 in.	15	50.5	757	5 in. by 3¼ in.	15.8	797
B	33,150	1¾	6 in. by 3 in.	18	60.5	1,080	6 in. by 3¼ in.	18.7	1,120
C	32,046	1⅝	6 in. by 3 in.	18	54.5	982	6 in. by 3¼ in.	19.8	1,080
D	33,150	1⅜	6 in. by 3 in.	18	58.0	1,020	5 in. by 3¼ in.	15.7	912
E	40,758	1½	6 in. by 3 in.	18	53.25	958	6 in. by 3⅞ in.	22.9	1,220
F	40,758	1⅛	6 in. by 3 in.	18	53.5	963	6 in. by 3⅞ in.	22.9	1,220
G	67,173	1½	7 in. by 3 in.	21	56.25	1,180	8 in. by 4½ in.	36.0	2,020
H	73,800	1½	5½ in. by 3 in.	16.5	65.25	1,078	8 in. by 4¼ in.	33.9	2,210
J	51,041	1 1/16	6 in. by 3 in.	18	65.25	1,175	6 in. by 3½ in.	20.6	1,345
K	30,222	1⅝	5 in. by 3 in.	15	36.0	540	6½ in. by 4¼ in.	27.4	985
L	33,699	1⅝	5 in. by 3 in.	15	36.0	540	6 in. by 5 in.	30.4	1,095

Draw Pins

If the pin is short between the pockets, it may be considered as under double shear stress. As the material is 0.8 as strong in shear as in tension (assuming the same

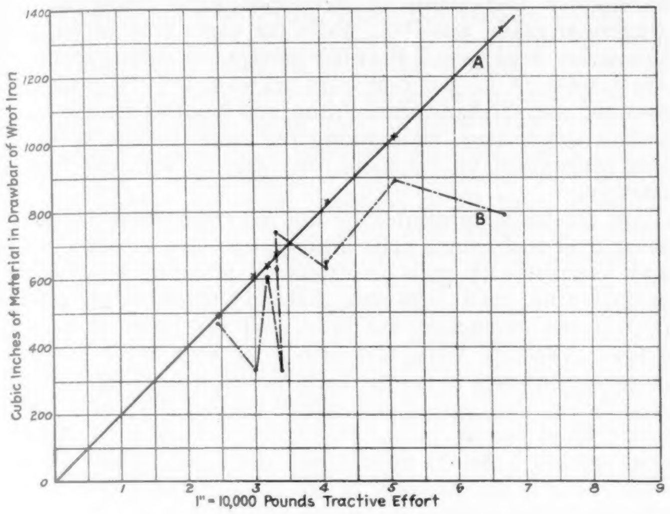


Fig. 2—Comparison of Actual Drawbars with Sizes from Proposed Formula

material is used for pin and drawbar) then twice the area of the pin must equal 1¼ times the sectional area of the drawbar, or

$$A_p = 0.625\ A$$

$$= 0.625\ \frac{Td}{50\,l} = \frac{Td}{80\,l} \quad \ldots\ldots (10)$$

If the pin is long, it must be treated as a beam loaded at the center with the "momentary load" and using a stress of $(.8 \times .94) = .75$ of the ultimate stress of the material. The "momentary load" may be found from equation (7) by multiplying the value of f by the area of the drawbar.

Taking f at 52,000 lb. per sq. in. as in equation (9), the "momentary load" becomes 52,000 A

$$\text{Bending moment of pin} = \frac{Wl_1}{4} = \frac{52{,}000\ Al_1}{4} \quad \ldots\ldots (11)$$

Where l_1 = length of pin between pocket.
Bending moment = stress × modulus of section.

$$\text{Hence } 13{,}000\ Al_1 = f_1\ Z \quad \ldots\ldots (12)$$

$$13{,}000\ Al_1 = .75 \times 55{,}000 \times \frac{\pi D^3}{32}$$

$$D^3 = \frac{32 \times 13{,}000\ Al_1}{41{,}250 \times \pi}$$

$$D = \sqrt[3]{3.22\ Al_1} \quad \ldots\ldots (13)$$

substituting value of A from equation (9)

$$\sqrt[3]{3.22\ \frac{Td}{50\,l} \times l_1}$$

$$D = \sqrt[3]{3.22 \times l_1 \frac{Td}{50\,l}}$$

$$= \sqrt[3]{\frac{Td\,l_1}{15.5\,l}} \quad \ldots\ldots (14)$$

The formulas may be summarized as follows:

T = Tractive effort in lb.
A = Area of body of bar in square inches
l = Length of bar in inches
d = Total amount of slack in eyes including a maximum allowance for wear in inches
V = Volume of drawbar in cubic inches
l_1 = Length of draw pin in inches
D = Diameter of draw pin in inches
For wrought iron of 55,000 lb. tenacity.

$$\text{Drawbar } V = \frac{T.d}{50} \text{ or } A = \frac{Td}{50\,l}$$

$$\text{Long pin } D = \sqrt[3]{\frac{Td\,l_1}{15.5\,l}}$$

$$\text{Short pin } D = \sqrt{\frac{Td}{62.8\,l}}$$

For mild steel of 80,000 lb. tenacity

$$\text{Drawbar } V = \frac{T.d.}{94.25} \text{ or } A = \frac{T.d}{94.25}$$

$$\text{Long pin } D = \sqrt[3]{\frac{Td\,l_1}{29.45\,l}}$$

$$\text{Short pin } D = \sqrt{\frac{Td}{118.4\,l}}$$

These formulas are offered as a more logical basis of design than that of the A. R. A., yet because of the unknown influence of the surroundings and connections to the drawbar some other numerical factors than those given may be more suitable. Those given, however, should provide bars that are safe under nearly all conditions. In this connection mention may be made of one railroad that gave dimensions and tractive effort, but no formula for a series of bars. Upon checking these in the manner here set forth, they were in practically all cases found to conform to the equation $V = \frac{Td}{55}$ for wrought iron bars.

Is Mechanical Firing Reducing the Cost of Train Operation*

THE outstanding features of stoker firing are the possible increase in tonnage or decrease in time between terminals, or both, together with the possibility of handling a fuel of a lower B. t. u. value and a corresponding lower cost.

As an offset against these considerations, which directly affect the cost of train operation, there has always been charged the increase in coal consumption per 1,000 gross ton miles, which has always been considered as going hand in hand with stoker operation. In the early development of the stoker the only successful machine was one having a relatively high point of delivery, and, consequently, when the locomotive was being forced to its maximum the lighter particles of coal were carried over the arch, where arches were used, thereby resulting in an excessive stack or spark loss. In recently conducted road tests it has been found that this condition no longer prevails. It was shown that where the same attention was given the stoker as in hand firing, the fuel consumption per 1,000 gross ton miles per hour was generally lower on the stoker-fired locomotive. This difference in fuel consumption was no doubt due to the higher average temperature obtainable in stoker firing, due to the elimination of the periodical inrush of cold air, and the more perfect combustion possible through carrying a lighter fire as well as the more regular and uniform fuel feed.

The data in the table was obtained as the result of a careful test conducted on a trunk line road to determine the difference between assigned and pool service.

FUEL PERFORMANCE OF U. S. R. A. LIGHT MIKADO TYPE LOCOMOTIVES EQUIPPED WITH STOKERS

February, 1922	Assigned service	Pool service
Engine No.	652	656
Engine miles	3,150	3,703
Gross ton miles	4,514,835	4,496,685
Pounds coal between terminals	476,710	605,530
Pounds per 1,000 G. T. M.	105.59	134.66
March, 1922		
Engine No.	652	656
Engine miles	3,750	6,144
Gross ton miles	5,129,449	7,723,177
Pounds coal between terminals	580,862	913,279
Pounds per 1,000 G. T. M.	113.24	118.25

*Abstract of report at Traveling Engineers' Association convention, Chicago, November, 1922.

The test extended over a period of 60 days. The two locomotives were identical in every respect, and operated in the same class of service, viz., fast freight. Locomotive No. 652 was operated by the same crew throughout the entire test, while locomotive No. 656 was handled by four crews alternating. Note that during the first 30 days the assigned locomotive made 18,150 more ton miles and 553 less engine miles than the pooled engine, and consumed 128,820 pounds less coal or a difference of 27.5 per cent calculated on a 1,000 gross ton mile basis.

At the end of the first month it was possible to make an immediate comparison which showed up the above difference in coal consumption. Steps were therefore taken to bring the performance of the pool crews to that of the assigned crew by teaching and getting the men interested, and the result of this action is reflected in the results for March.

While these results show an increase of 7.3 per cent in fuel for the assigned engine, this increase was due almost entirely to weather conditions. The table shows, however, that the active supervision over the pool crews, together with their co-operation, resulted in a decrease of 13.8 per cent. As the weather conditions affected both alike, it is reasonable to assume that had the pool crews been allowed to go on during the month of March as in February, the coal consumption for Engine No. 656 would have been affected the same as in the case of Engine No. 652, i. e., increased 7.3 per cent, which would have made it approximately 144.49 lb. per 1,000 gross ton miles instead of 118.25 lb.

This test proves, first, that the excess in fuel consumption of the pooled over the assigned engine was not due to the stoker or the locomotive, but altogether to the manner in which it was handled by the four crews; and, second, that intelligent supervision will bring the same results in case of stoker as in hand firing.

Economical train operation means the movement of the greatest possible tonnage over a division in the shortest possible time. Where the coal consumption per hour approaches the physical limitations of the fireman, it is only through the application of the stoker that a uniform maximum steam pressure is possible at all times, and it is only through the maintenance of the maximum steam pressure that the desired speed can be sustained.

Opinions vary as to the size of the locomotive to which the application of stokers seems justified. A certain railroad in the Southwest, where temperature ranges are high, operated consolidation type locomotives of 45,000 lb. tractive effort, 49.5 sq. ft. grate area, over two divisions, one being 117 miles long of practically one per cent continuous grade, the other 124 miles long with one per cent broken grades, the longest continuous grade being 40 miles. The rating of the locomotives when worked to their capacity was 1,500 gross tons. Owing to the physical limitations of the firemen it was found necessary to reduce the tonnage over the first district to 1,150 gross tons and over the second to 1,250 tons in order to get the trains over the road within the sixteen-hour period. Stokers were afterward applied to these locomotives and the tonnage raised to the locomotive capacity; i.e., 1,500 gross, or an increase in the first instance of 30 per cent and in the second of 20 per cent. As the wages remained the same, this change resulted in a corresponding direct decrease in operating cost. In this instance it was not a question of the size of the locomotive so much as a question of climatic conditions and physical characteristics of the railroad.

We now cite a case where the locomotives were so large that when worked to their capacity the firemen were unable to supply the coal as fast as the engine could burn it. These were of the 2-10-2 type, 67,000 lb. tractive effort, 80 sq. ft. grate area, operated over a choppy division 100 miles long having short grades of 1½ per cent. The tonnage behind these engines when hand fired was 2,350 gross tons. Stokers were applied and the tonnage increased to 2,650 gross or 12.76 per cent. The wages and other costs remained the same.

In some very exhaustive tests conducted in the Dominion of Canada during the months of May and June, 1921, with Mikado type locomotives, 53,000 lb. tractive effort and 56.5 sq. ft. of grate area, it was found that the maximum drawbar horsepower that could be developed hand firing on the maximum grade was 996, while the same type of locomotive stoker fired gave a drawbar horsepower output of 1,227, an increase of 22 per cent. An increase of 300 gross tons over the normal hand-fired rating was handled by the locomotive stoker-fired, maintaining the same average speed as was maintained by the hand-fired engines with the lighter tonnage.

On the road represented by the chairman, there is a seasonal fruit rush which calls into service every available man and locomotive to such an extent as to make it necessary to double the road (150-mile division) wherever the condition of the locomotive, the crew, and the hours of service make it possible. When this rush is on, we find no difficulty in getting the men to double back on stoker-fired locomotives even though they have a stoker-fired engine in but one direction. Therefore it is clear that if we did not have stoker-fired engines it would mean either more men, which would often result in the payment of the arbitrary held from home terminal, or in holding the engines for the crew's rest, or in an increase in the number of engines assigned to this service which would mean an increased number of idle engines during the slack period. An idle engine costs money even if standing dead behind the roundhouse, as it represents an investment on which the interest will run from $10 to $15 per day.

The above simply represents the definite decrease in cost of train operation as developed on different railroads through the application of stokers to locomotives of different dimensions.

There is, however, another decrease in cost of train operation which can be directly attributed to the application of the stoker, but which varies with the seasons and climatic conditions of the states traversed by the railroads. We refer now to the necessity of sending out relief firemen to take the place of others who on account of the extreme heat or through other causes have become physically exhausted. The committee has records of one railroad located in the Mississippi Valley having one division 156 miles long, operated by locomotives developing 39,000 lb. tractive effort where during the summer months it is necessary to have relief firemen stationed at intermediate points 50 miles apart, and as a rule one or more firemen are relieved daily. As under the schedule, 100 miles or less constitutes a day's work, it follows that in a case of this kind the labor cost insofar as firemen are concerned, is doubled. This in itself would not amount to so much, provided there is no attendant train delay, but where it is necessary to tie up a train at some intermediate station until a fireman has been deadheaded from a terminal, it results not only in an increased labor cost, but it upsets the dispatcher's entire schedule, delaying not only the train in question, but often other opposing trains.

Going back to the Canadian test previously referred to, it was found that the maximum speed on the grades possible with the hand-fired locomotives was 12.42 miles per hour, while with the stoker-fired engine handling the same tonnage a speed of 15.61 miles per hour was maintained, or an increase in speed which is equivalent to an increase in ton-miles per hour of 25 per cent.

It is on account of the speed factor not being considered that in many instances the mechanical stoker has been charged with an increase in fuel consumption over hand firing. Ton miles or train miles or locomotive miles are poor yardsticks by which to measure train or locomotive operation. The time element should always be taken into consideration

and where this factor is considered and coal consumption as well as other operating costs are based on the ton miles per hour, it will be found that the stoker can show economies over the best hand firing.

In the beginning of this paper we referred to one possible reduction in operating costs through the possibility of burning a cheaper grade of fuel. During the last months in 1921 slack coal, or what is termed screenings, became a drug on the market and could be purchased at $1.20 per ton less than the mine-run coal produced at the same mines. A saving of $1.20 per ton held out a very attractive proposition to the railroads, but it was found that in hand-firing practice it could only be handled successfully in switch engines, as in road service the firemen experienced considerable difficulty in maintaining full steam pressure at all times in either passenger or freight service. Tests were conducted to determine whether or not the coal could be successfully used in connection with mechanical stokers, and it was found that with some types of stokers practically the same locomotive horsepower output could be obtained per pound of screenings as per pound of mine-run, and therefore on such roads as were equipped to handle both mine-run and screenings at their coaling stations, screenings were used in the stoker-fired locomotives, resulting in a net saving in fuel cost of 7.6 cents per locomotive mile—more than enough to offset the wages of the fireman.

The report is signed by James Fahey (N. C. & St. L.), chairman; A. L. Bartz (E. P. & S. W.), Joseph Keller (L. V.), William Lowney (G. N.), and F. P. Roesch (Standard Stoker Company).

Discussion

The trend of the discussion bore out the conclusions in the report that fuel consumption with stokers firing, when measured on a ton mile basis, is more economical than hand firing. Of course, the only direct comparisons which can be made are with locomotives of less than about 50,000 lb. tractive effort, since engines of greater capacity are beyond the limit of practicability for hand firing.

Considerable attention was given to the question of spark losses in the discussion and it is evident that while these losses were large with some of the early stokers, they are now no longer serious, even when slack coal is being burned. On the Baltimore & Ohio the steam from the stoker exhaust is being diverted into the stoker barrel, where it serves to moisten the coal slightly and to hold it in the firebox long enough for complete combustion to take place. It was suggested that eventually it will be impossible for the railroads to procure screened coal at the mine because of the difficulty of disposing of the screenings and that it will become necessary to purchase mine run coal. It was brought out that this is already the case in some districts. The railroads should, therefore be prepared to burn coal economically with any percentage of slack that may be produced at the mine.

The design of the grate is also receiving attention in connection with stoker firing. The Santa Fe is replacing finger grates with table grates having circular instead of slotted air openings in territory where Gallup coal is being burned. This has effected a reduction both in the spark losses and the loss of unburned fuel through the grate. The Pere Marquette is also applying the table grates on stoker fired locomotives. On the Wabash it was brought out that the standard finger grates are being replaced with Hulson grates. Stress was also laid on the need for high standards of stoker maintenance, particularly of the distributors, to insure that the fuel be uniformly distributed over the grate.

Very little was said about stoker failures. Although the members taking part in the discussion generally admitted that there are stoker failures, it is evident that they are of no more frequent occurrence than the failure of other parts of the locomotive and that they have not had any detrimental influence on the miles per engine failure.

Material and Equipment Prices

THE downward trend in the prices of practically all materials, which began in the fall of 1920 and continued through 1921, was in most cases checked in the first part of 1922. The latter half of the year was characterized by an increase in the prices of most commodities, as a result of which railroads must now pay from 7 to 70 per cent more for their supplies than a year ago. A better knowledge of the changes which have taken place and an approximation of the current prices can be obtained by considering various classes of materials by themselves.

Lumber. The lowest mill prices for Douglas fir were reached in November, 1921; since then there have been several advances. As illustrations of the changes in prices from the low figures to those prevailing at the end of 1922, car sills advanced from $18 to $30 per thousand feet board measure, car framing from $15 to $26, car decking from $19 to $27, car lining from $20 to $27, and car siding No. 2 from $45 to $58. Mill prices of Southern pine began to advance in April, 1922, and by the end of the year car sills had increased in price from $32 to $46, decking from $26 to $34, siding from $52 to $62, and lining from $25 to $35.

Iron and Steel. The prices of many steel products began to advance slightly early in the year. There were marked advances in the fall, largely due to the shortage in fuel, which was followed by some decline in November and December. Car axles increased from $2 to $2.50 per 100 lb., and chilled iron car wheels from $1.75 to $2.10 per 100 lb. Prices for scrap, pig iron and castings showed proportionate advances.

Coal. The recent coal strike has been extremely costly to the railroads, the average cost of the coal used in August and September being about 30 cents a ton greater than the peak prices in 1920. The roads suffering the most were those in the Great Lakes and Northwestern regions, where from a low cost of $3.86 in March the cost had risen to $6.01 in September. The regions least seriously affected were the Pocahontas and the Southern. In the Pocahontas region the range was from $2.44 to $3.22 per ton, and for the Southern region from $3.01 to $3.12.

Cars and Locomotives. The prices of cars and locomotives followed the trend of the basic commodities entering into their construction. From the level of the period between 1910 and 1914 there was a rapid rise to the peak of 1920. Using 100 as the index number for the 1910 to 1914 period, the peak prices were 251 for locomotives, 300 for all-steel freight cars, 313 for composite wood and steel freight cars, and 218 for passenger coaches. Orders placed during the latter part of 1921 were from 30 to 50 per cent below the peak prices. Present prices are approximately half way between the peak prices and the low figures of 1921. From information made public by the Interstate Commerce Commission in connection with equipment trust certificates it appears that prices in 1922 were approximately as follows: Passenger coaches from $20,000 to $24,000, express and baggage cars from $17,000 to $20,000, dining cars from $35,000 to $45,000, passenger train refrigerator cars about $7,000, box cars from $1,500 to $1,850, gondola and hopper cars from $1,500 to $1,800, flat cars from $1,200 to $1,400, stock cars from $1,200 to $1,700, and refrigerator cars from $2,400 to $2,800. Locomotive prices varied with the type, the weight, character of equipment, etc. Mikado (2-8-2 type) locomotives ranged in price from $36,500 to $55,000, while some of heavy weight and equipped with boosters and other appliances cost $72,000; Pacific (4-6-4 type) locomotives ranged in price from $40,000 to $63,000, the latter being equipped with boosters. Eight-wheel switch engines cost from $32,000 to $36,000, and six-wheel switch engines from $28,000 to $32,000.

Advantages of Diesel Electric Locomotives*

Co-operative Research Bureau Advocated to Develop This Type of Equipment for the Railroads

By L. G. Coleman

Assistant General Manager, Boston & Maine

FOR the past twenty-five years American railroads have been under severe criticism from many quarters and have suffered much regulation. The criticism in the past has been largely unintelligent, the result of more or less well-founded resentment of railroad practices, but producing legislation of not very constructive nature. One does not have to be a prophet to say the probabilities are that during the next two or three years criticism and regulation will be more severe than in the past, with, however, this difference,—it will be more intelligent and probably more unfair. It would appear necessary for the railroads to clean house, to make every effort to take advantage of modern ideas and methods, made possible by the rapid industrial development occasioned by the war. We have been disposed to be very conservative, to hesitate to adopt new methods. Criticism of this failure, while frequently not taking into account financial impossibilities, nevertheless has stuck, and it is one that we must combat, preferably, where possible by deeds rather than by argument. It is time to do—not to talk.

The Need for Co-operative Research

Two or three years ago the mechanical officers of the American Railway Association were asked to make a recommendation as to the advisability or desirability of establishing a research bureau. A committee was appointed to consider the matter, and after much discussion an inconclusive report was handed down, not because a majority did not think such a bureau was desirable, but, I am informed, because they doubted the possibility of obtaining necessary funds. So far as I know, the matter has never again been considered.

The railroad business is the largest single homogeneous industry in the United States. All of our major problems are common ones. Yet, any investigation along new lines, where any money expenditure is involved, whether it concerns mechanical, maintenance of way, or operating methods, must be made by individual railroads, or companies that supply their physical wants. Any real development usually requires a combination of products of companies manufacturing widely different articles. It is not reasonable to expect them to spend a great deal of money in experiments which may or may not lead to any direct gain to them. They would naturally wish to guide any development along lines requiring the least possible departure from the use of existing products, when the best result might require a complete new design.

Problems Requiring Joint Investigation

There are many applications of modern mechanical methods used in other industries which if assembled will develop a machine or process producing a saving in operating costs to the railroads. To apply these, however, much money must be spent in redesigning and experimenting, money running into millions of dollars. The only reasonable source of such funds is the railroads themselves. A central research bureau with sufficient income to obtain as needed the services of the foremost men in the country, and to finance the necessary experiments, would be of invaluable aid. The expense pro-rated would be small to each individual. The railroads are not competing with each other in money-saving devices, and as a body could experiment more efficiently and cheaply than independently. For instance, the application of gas and electricity to various railroad services, the co-ordination of motor trucks and automobiles to railroad business, the development of a manufactured tie, automatic train control, are all questions which such a bureau could efficiently and economically handle. A real service will be rendered if the mechanical and maintenance of way officers will push this matter to a conclusion.

Shortcomings of the Steam Locomotive

There is another question which in my opinion is the largest of any that such a bureau alone can practically solve. I think there will be no dissent to the statement that the steam locomotive today is probably the most uneconomical and unsatisfactory machine in industry. We have made enormous improvements, that, granting its inherent original weakness, have very much increased its efficiency as far as a power producer is concerned, but these same improvements have so increased the cost and difficulty of maintenance that the time lost in terminals practically wipes out the savings due to fuel economy obtained by modern devices, and increased unit power.

The inherent weakness of the steam locomotive is its boiler. The most efficient possible construction and maintenance of a steam boiler cannot overcome the absolutely necessary delays such as caused by washouts, hydrostatic tests, renewals of arches, cleaning of flues, examination of and repairs to grates, front ends, etc. The limiting factor of long engine divisions is usually the boiler, not the machinery. Therefore, regardless of the most efficient possible maintenance there will, due to this weakness, always be lost time in terminals by a machine that is otherwise ready for service, which can be conservatively put down at 50 days each year.

Cost of Electrification Is Prohibitive

For some years the railroads have been striving to overcome this difficulty. The remedy that has been generally grasped is electrification. Its principal weakness is the large first cost and the necessity for more or less constant load to get a high efficiency factor. Except in very few instances an approximately uniform volume of freight is unknown to railroads, nor can it be expected in the future. When a division is fully electrified, unless the entire system is brought to the same condition, flexibiliy is decreased. The electric locomotives cannot be used off the electric division. If the full efficiency of electrical operation has been obtained by doing away with coaling plants, ashpits, and other necessary adjuncts to steam operation, conversely steam power cannot be used on an electric division. This means, to take care of emergencies, an excess of electric power on the electric division and an excess of steam power on the steam divisions, where as a smaller surplus of power that can be used interchangeably will take care of two or more divisions. To obtain full benefit from electrical operation requires com-

*Abstract of a paper presented before the New England Railway Club, Boston, January 9, 1923.

plete electrification, and the first cost is frequently prohibitive.

There is little doubt that we will be unable to get much further economies as long as we continue to carry a portable steam boiler on each of our power plants, many of the economies in power production being lost by the increased terminal delay due to maintenance. To summarize briefly, the delays incidental to use of the steam boiler that can be avoided *in toto* by its abolition—washouts, hydrostatic tests, repairs due to leakage, firebox and front end maintenance, delay on ashpits and at coaling stations, and the extra expense of maintaining ashpits, coaling plants, water stations, and the delay incidental to taking water en route. Do away with the steam boiler and we do away with these delays and the ensuing costs.

Excessive Time for Repairs Increases Operating Cost

Owing to complications to modern train service schedules, many railroads are put to considerable expense if train and engine crews are delayed away from home terminal. Excessive repairs to locomotives not only mean loss of revenue upon the investment as well as increased facilities to take care of them while lying idle excessive time, but also the overtime expense due to crews held away from home, which often is a large item. It is fast approaching a state where we not only cannot double crew engines, but require more engines than crews in order to keep crews moving. This is inefficient operation. The modern locomotive has become a very expensive machine and it should be in revenue-producing service at least seventy-five per cent of the time instead of the very small percentage it now is.

There are many things that we can do and many improvements we can make that will whittle this down, but as long as we use the steam boiler the main delay will remain, and the more complicated we make the locomotive, the greater this delay is going to be and the greater the resulting expense. Most of the devices for improvement to the steam locomotive have aimed at increased boiler efficiency—superheater, feed water heater, stoker, flue blower, etc. Isn't it time to forget the steam boiler and start out with a clean slate to see if there is not some other modern method to meet our problem?

Possibilities of Diesel Electric Locomotives

There has been great development of the Diesel engine in the past five years, but only the surface has been scratched. Such engines have been projected for stationary service that will weigh in the vicinity of ninety pounds per horsepower, in which design the question of weight has not been a primary factor. Competent Diesel engine designers say that there is no reason why such engines may not be built at least as light as sixty pounds per horsepower.

A modern Sante Fe type locomotive with fully loaded tender weighs approximately 283 tons. An electric locomotive of similar tractive effort can be built at about 130 tons, and will require available at its maximum point of consumption 1,800 kilowatts. Under accepted practice this power is generated in a central stationary power plant and distributed by means of a trolley or third rail. If we can produce the current required for each electric locomotive in a movable power plant which may be attached to that locomotive, we can obtain the advantages of the electric locomotive and dispense with the disadvantages of the steam boiler.

To produce 1,800 kilowatts requires a brake horsepower of about 2,600. At 60 pounds per horsepower, this would require one or more Diesel engines of an aggregate weight of 78 tons, one or more generators not over 12 tons, a chassis to carry this load, say 40 tons, leaving 20 tons for radiation and auxiliaries. To recapitulate, for 280 tons, the same approximate weight as a Santa Fe, we may assemble a flexible, movable, fully self-contained power plant and locomotive, driven by Diesel engines using low-grade fuel, that will be at least as economical as coal, with none of the disadvantages of the steam boiler.

Design Provides Great Flexibility

The possibilities in design are so varied as to offer many opportunities for economies. Great flexibility is possible. The locomotive can be in one unit; the power plant another. The power plant itself can be subdivided. For example, the unit I have proposed would probably be made up of three or four Diesel engine generator sets mounted on a single chassis. This assembly could be so arranged that in case of failure of one of the power sets it could be replaced quickly by a spare unit and the whole restored to service in a few hours. By building the motor and power units separately they could be interchanged in case of heavy repairs being required by either.

In case of failure of one generator set the remaining ones would still be able to handle a considerable train instead of causing the complete failure that would follow a similar occurrence with one large power unit.

The electrical combinations as to voltage and amperage are increased by the possibility of hooking the units up in series or parallel. The machinery of the power plant can be under constant observation as in any stationary plant, and when one unit is cut out by reason of reduced power demand, it can receive minor adjustments without delay to the train. When such a locomotive is designed, it will be possible to run it much longer mileage between repair points than the most efficient steam engine.

I have in this brief discussion used the Diesel engine as the foundation of the scheme, because up to date it has been the most economical power producer available for the use I propose.

Other Types of Engines May Be Suitable

I am not at all sure, however, after full investigation and study, that the gas engine as used in automobiles and airplanes may not work out more successfully than the Diesel engine. The main obstacle to its use at the present time is the cost of fuel for such an assembly. It does not necessarily follow even at the present wholesale price of such fuels that the decreased weight, and first cost, and the greater flexibility gained, will not very nearly counterbalance the fuel saving of the heavier Diesel type.

There is another to me very interesting possibility which such a development would bring forth, namely, the use of fuel alcohol. If an engine should be developed using alcohol and there was any prospect of its being used in quantities, the next step, namely, a cheap supply, is a comparatively simple matter and need not be a stumbling block.

There is a third possibility, namely, the use of the Diesel engine direct, without any other than mechanical means of transmission of power. It, as you all know, has received some attention in Europe. This does not appear to me to hold forth the same promise as the use of electric transmission with its very much greater flexibility.

Research Needed to Reduce Cost of Operation and Maintenance

I have for obvious reasons only outlined this scheme in its broadest aspects. I have used only approximate weights and general description, but they are all within limits of known practice. To bring it to a successful issue will require the most painstaking work of experts in Diesel engine and electric design and many experiments.

The cost of locomotive operation and maintenance is so great today, and so much greater than in the past, that it is the most serious problem facing all railroad officers and needs heroic treatment.

To make such an investigation is out of the question for any road. It will be a light burden, if borne by all.

I believe the steam locomotive is out of date.

I believe that it is perfectly feasible to develop an equally powerful and more economical gas-driven locomotive.

I believe the railways of the country should establish a research bureau to investigate this and other matters of supreme mutual advantage.

I believe that such a bureau should be controlled by a very small committee to take complete responsibility for investigations entrusted to them, at least one and not more than three members giving their exclusive time to this work, having sufficient funds to employ temporarily, when needed, the best known experts in the world, and to finance the necessary experiments.

Whether you believe in this proposal or not, the need of a research bureau must be apparent. Use your influence to produce a resolution demanding the funds. I say "demand" because I believe the word is warranted. The maintenance officers are held responsible and should have the courage to insist upon their needs.

Discussion

Practically all who took part in the discussion endorsed Mr. Coleman's proposal to establish a co-operative research bureau. Most of the speakers took exception to the statements that the steam locomotive is inefficient and out-of-date.

G. M. Basford expressed the opinion that the locomotive should not be blamed for the fact that it is in advance of the methods of using, loading and maintaining it. Modern locomotives require increased attention, but they do so much more work that the additional expense is a paying investment.

W. E. Woodard, of the Lima Locomotive Works, stated that a research bureau rightly conducted could help greatly in the development of the locomotive, though in the past the need had been partly met by the research conducted by the Pennsylvania Railroad and the University of Illinois. He did not believe that the steam locomotive could be considered out-of-date until satisfactory equipment was available to take its place. The extremely high first cost appeared to be one of the important disadvantages of the equipment proposed by Mr. Coleman.

F. J. Carty (Boston & Albany) challenged the statement that the low efficiency of the steam locomotive is due to the boiler and pointed out that only 19 per cent of the defects reported by the federal locomotive inspectors were chargeable to the boiler and its appurtenances. There seemed to be some question as to the reliability of the Diesel engine and this defect would make it unsuitable for railroad service.

L. C. Winship (Boston & Maine) pointed out that the cost of the equipment proposed by Mr. Coleman would be so great that in some cases it would be cheaper to provide electric locomotives with central power stations and overhead conductors to distribute the current.

H. Montgomery (Rutland Railroad) questioned whether the railroads were getting full economy from modern locomotives and advocated more thorough training of employees to remedy the situation.

G. E. Ryder (Superheater Company) called attention to the high efficiency of modern locomotives and compared the size and the performance with a stationary power plant of the same horsepower, which required a building 114 by 120 ft.

H. Bartlett (Baldwin Locomotive Works) stated that the locomotive builders were on the alert for improvements, not only in the steam locomotive, but also in anything that might supplant it, but he found that respect for the steam locomotive was increased by comparison with possible substitutes.

C. B. Smith (Boston & Maine) also stated that finding any equipment to take the place of the steam locomotive was a difficult problem.

In closing the discussion Mr. Coleman pointed out that those who defended the steam locomotive dwelt on its efficiency while in service, whereas he considered the crucial question to be the excessive time which the equipment spent out of service. He stated that high-speed Diesel engines are now being developed which make the internal combustion engine more adaptable to railroad work.

Four-Cylinder Tank Locomotive for North Staffordshire Railway of England

An interesting suburban locomotive of new design has been built recently in the railroad shops at Stoke-on-Trent. The four cylinders, 14-in. by 24-in., are all connected to the middle axle. A special feature is the arrangement of cranks; those outside and those inside the frames are set at 90 degrees apart respectively, each outside crank being at 135 degrees respectively to the corresponding inside crank on the same side. The four 8-in. piston valves are actuated by four gears of the Walschaert type. The wheels are 54-in. in diameter and the wheel base 16-ft. 6-in. The boiler carries 175 lb. pressure and has 488.6 sq. ft. of heating surface in the tubes, 261.3 sq. ft. in the flues and 106.8 sq. ft. in the fire box while the superheating surface is 195 sq. ft. The grate area is 17.5 sq. ft. The coal capacity is 2½-tons and the water capacity 1080 U. S. gallons. The weight in working order is 126,900 lb. The rated tractive force is 14,800 lb. and the cylinder horsepower 1,235.

Essential Elements of the Human Problem*

"Scientific Management" Must Be Broadened—Employers as Well as Employees Need Education

By E. M. Herr

President of the Westinghouse Electric & Manufacturing Company

THE human problem in industry is not a new thing. During a thousand years of ancient times, for the most part before the Christian era, self-supporting and self-regulating organizations of workmen existed, which were remarkably similar to the trade unions of today. They were publicly acknowledged and legislative enactments made to control them. But they were weakened under the reigns of successive tyrants and finally lost with the Christian massacres of Diocletian in the early part of the fourth century and the subsequent feudalism of the dark and middle ages. The immediate cause of the destruction of these far-reaching labor organizations seems to have been the coveting of their wealth and power by the rulers of the day. * * * Constantine in A. D. 337 recognized 35 crafts—architects, brass and copper smiths, blacksmiths, carpenters, decorators, doctors, founders, fullers (cloth), furriers, glaziers, goldbeaters and gilders, goldsmiths, ivory workers, joiners, looking-glass workers, lapidaries, masons, marble cutters, plasterers of various kinds, pearl and filigree workers, potters, painters, plumbers, pavers, sculptors, silversmiths, stonecutters, statuaries, veterinaries, wagon makers, workers in mosaic. There were many strikes, usually called historically, when they attained sufficient proportions, "servile wars." The greatest and last of these was the uprising led by the gladiator Spartacus. Practically all ended disastrously.

And so the tide of the human element in industry has ebbed and flowed through the centuries. The so-called English (industrial) revolution in 1760 marked the beginning of the factory system and a departure from isolated craftsmanship under oppressive landlordism. * * * As late as 1820 less than five per cent of the American people lived in cities with a population of 8,000 and over. Today we are the greatest manufacturing nation in the world and over half of our population are city dwellers. In Massachusetts from 1800 to 1815 laborers received from 35 to 75 cents a day; carpenters and blacksmiths about $1.00, and women employed as domestic servants their board and 50 cents a week. About 1825 occurred the first strike for a ten-hour day. "Sweatshop" methods had then begun. Local trade unions sprang up more or less intermittently early in the century, principally in the shoemakers' and printers' trades, both for mutual benefit and insurance, and for the reduction of working hours and the increase of wages, but it was not until the fifties that national organizations began to take effective form. These were pretty well shattered by the depression preceding the civil war and did not really come into being until the seventies and eighties.

[The speaker here reviewed the development of manufactures in this country, showing, from the census of 1920, that 40 per cent of the inhabitants support the whole, directly or indirectly.]

Principles Underlying the Human Problem

Let us now turn our attention more directly to this problem in an endeavor to ascertain at least some of the directions toward which its solution trends. The principal new thing about the problem is that industry is now conducted on a scale larger than ever known before. The problem has been intensified by the greatly increased size of manufacturing establishments, by the concentration of population in cities having a large foreign element of often radical tendencies, and by the insecurity of employment, in which business cycles play a large part.

The underlying labor unrest and distrust are born of fear and misunderstanding—fear of coercion, unemployment and sickness—and a lack of mutual confidence as between employer and employed. There is more liberty and consideration for the workers than has ever been known before, and with it has come to the workers the greater vision of what they believe should belong to them in welfare and happiness. The social responsibility of management is being emphasized as never before. The awakened worker of today, more sensitive than his predecessors, intelligent, critical and perhaps irritable, must be convinced of the ability of management as well as its good faith, and in extreme cases even of the necessity of its being. It is said that democracy without management reverts to despotism on the mere ground of its inefficiency, and that the fundamental error in the recent Russian failure was confiscation of the factories and the expulsion of the managers, with the resultant breakdown of discipline and credit, on a false theory that labor alone creates wealth, whereas management, with credit and good faith, is of the first importance in the process of production. * * * It is the duty of the management of today to prove its "reason for being" and that the collective result of the combined efforts for managers and workers is a fine and great thing. If they can feel that this is the case, most men will toil cheerfully as subordinates. The management must convince employees by their experience that their treatment is fair and honest and without "bluff." It takes time to establish such confidence, and men will discover very quickly if the "boss" is not square. It must be established that labor and management are not foes.

The personnel department is now becoming common, but its intelligent extension still has far to go and it is regrettable that some companies have seen fit to curtail this activity in times of depression when they and their men need it most. These relations should not be handled and directed by the personnel department alone. The active heads and real managers are the ones on whom this responsibility must rest and who must handle it with their employees, not occasionally nor spasmodically but regularly and continuously, for work of this kind requires a great deal of time and patience. This effort on their part will gain the confidence of the employees and instil a spirit of co-operation throughout the organization, and it must be exerted on those directly in charge of the daily work of production. Anything less than this is futile and doomed to failure. Boards of directors must keep in mind this relation and work with the officers in determining policies which the managers can carry out without destroying valuable relations established only after long and patient work and almost impossible to renew.

Shop Representation Plans

One very large organization cites good results of five years' experience. * * * They find that if the men are free to make suggestions to the management they will not ask an outsider to do it for them. They find that workmen

*Abstract of an address delivered in New York City on Wednesday, December 6, before a joint session of the American Society of Mechanical Engineers and the American Economic Association.

are anxious to learn if given a chance, and they encourage the study in factory schools of the work of other departments. This broadens the employees' perspective and increases their interest in their own work.

It is credibly stated that at present there are in the United States more than 300,000 employees working under shop-representation plans created to give them a voice in the conduct of the shops in which they work, and that in by far the larger number of cases considerable progress has been made in establishing the most cordial relations between management and employees.

The crux of the industrial problem includes the question —How the just share of each party to industry is to be determined and how is each to be guaranteed its right to share progressively in increasing productivity, and be held also to the corresponding obligation to see losses proportionately shared? This obligation is often overlooked. Nominal wages have increased enormously, and it is safe to assert that real wages have also augmented despite the high cost of living and the fact that in the early days of industry few workers depended entirely upon their wage but were "found" many things which must now be purchased. * * * Manufacturers naturally wish to see their employees receive a wage, with reasonable working hours, which will support them in comfort. This, of course, is only possible when economic conditions will permit, as wages are not and cannot be based on the cost of living. If this condition is to obtain, the employee must live in accordance with his income and responsibilities and exercise frugality and care in his expenditures. Unless this is done, the real interest of the employer and employee will not be conserved because wages would be lifted to the point of throttling the industry.

Scientific Management

Scientific management—which is in fact little more than getting rid of confusion and perfecting adjustments, or in other words, good management—has entered largely in recent years into the human problem in industry. As helping to avoid undue strain on the part of the worker, and waste of time and materials, it should be of benefit to all concerned. It should remove the cause of any hostility to the broadest application of scientific knowledge of the conditions of maximum labor efficiency, to the gain of all parties to production. The scientific management which dealt in the earlier stage with individual output in an engineering way must now deal with men collectively and develop that scientific breadth of imagination and application which is becoming a vital necessity for the welfare of a modern civilized community. The psychology of labor, both in good and hard times, says Professor Commons, is fundamentally the psychology of a class of people whose life is insecure. The accident-compensation law has accomplished the first little step toward giving security to the job. It has shown that the only way to establish safety and security is by making it financially profitable to do so. And so shall we make it financially profitable to business to eliminate to a large extent the wage loss due to unemployment on account of sickness, on account of changes in seasons, and on account of fluctuations in business. Labor can never accomplish this result. The only possible accomplishment of it will come when the employer arranges to cover unemployment from sickness by some adequate form of insurance, to the expense of which the employee will contribute, indemnifying the employee against loss of employment from this cause (accident is now covered by our compensation law), and to lessen unemployment on account of the fluctuation in production because of changes in seasonal demand by the proper use of stocks of finished product so as to smooth out these fluctuations and also those due to abnormal variations in business.

Increased security and continuity of employment greatly lessen the human problem, but on account of lessened labor turnover and uniformity of production they also reduce the cost of the product. Many progressive industrial organizations have gone far beyond the requirements of the accident compensation laws and the safety of the worker, incurring large expense in providing liberally for free life insurance, advantageous savings and loan opportunities, housing, service pensions, and education.

Education, Economic and Moral

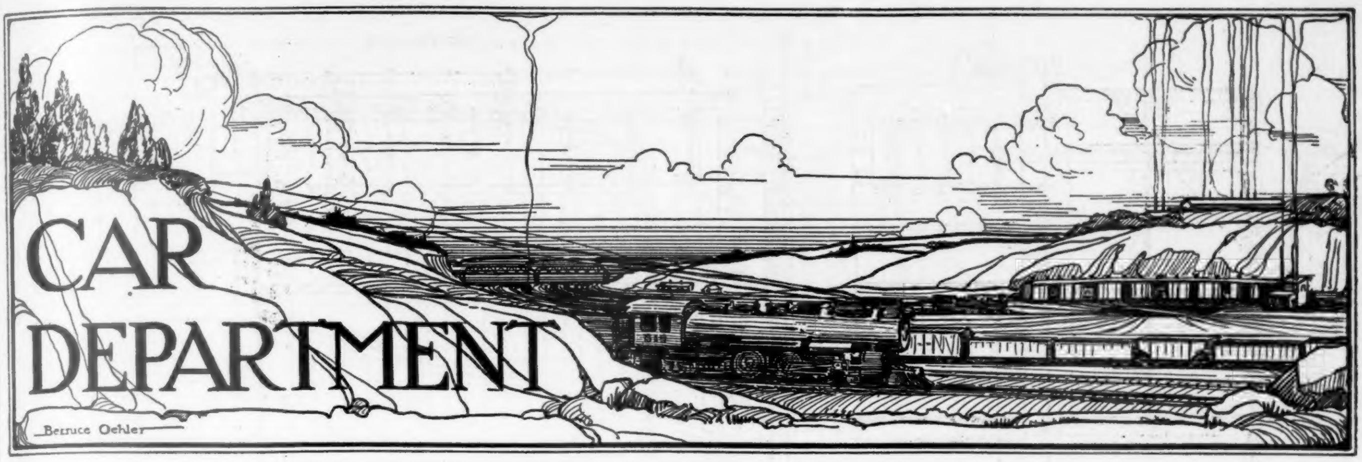
Additional phases of helpful education might well be tried; for example, how to make repetitive work, in itself monotonous, interesting. A knowledge of the "why" of their product and the use of it and of related products of other departments has been found to materially broaden the operator's perspective. Then, too, workers can be encouraged to exercise their ingenuity in devising means to lighten and quicken their work and thereby incidentally increase their earnings. With shorter working hours there arises the question of what to do with idle time. Any one who investigates the use to which the average employee devotes his leisure undoubtedly will be convinced that such employee would be much better physically, mentally, and morally if he had less idle time, for it is generally used in loafing or in amusements which consume a material part of his earnings without corresponding benefits.

Work well done and with a knowledge of progress is a source of enjoyment with many, taking the place of the recreation others find necessary to their happiness, but education of both sexes in ways in which to use leisure time profitably yet pleasantly is needed. The young should be taught thrift, for a thrifty person will not uselessly waste his leisure time. The human problem in industry cannot but be largely affected by example. H. G. Wells speaks of the disturbing influence of "the obvious devotion of a large and growing proportion of the time and energy of the owning classes to pleasure and excitement. This spectacle of amusement and adventure affects the imagination of the working man. In making labor a part of every one's life and the whole of nobody's life lies the ultimate solution of our industrial difficulties."

The human problem in industry is very complex and can never be entirely solved. To measurably improve the feeling of confidence of the employee in the employer we must always and fundamentally be absolutely honest in our dealings; not only honest in our actions but also in our thoughts and intentions. Unpleasant facts and information necessary to be told to the employees should be given them as honestly as the others, and very promptly, so as to give them as much time as possible to adjust themselves to difficult or distressing conditions.

Finally, is it not clear that at least one direction of the solution of the problem is along educational lines? First, education of ourselves, the employers, to a more general understanding of the spiritual, personal, economic, and physical relations involved; and second, education to encourage and aid in every proper way the general and vocational training of the employees in thrift, especially the younger boys and girls, but also the mature but still impressionable group of young men and women who are keen to learn how their position in the workaday world can be improved. Example in this effort to educate and train the employee is especially effective. Such educational effort should establish confidence and encourage co-operation. It should also be directed so as to develop individuality in each workman and woman.

Let us therefore substitute the rule of reason and intelligence for force and so endeavor to restore in America the freedom of the individual, be he employer or employee— "that freedom which enables the young man to look into the future with confidence, knowing that the only limitations to his achievements are the boundaries of his intellect and the measure of his energy."

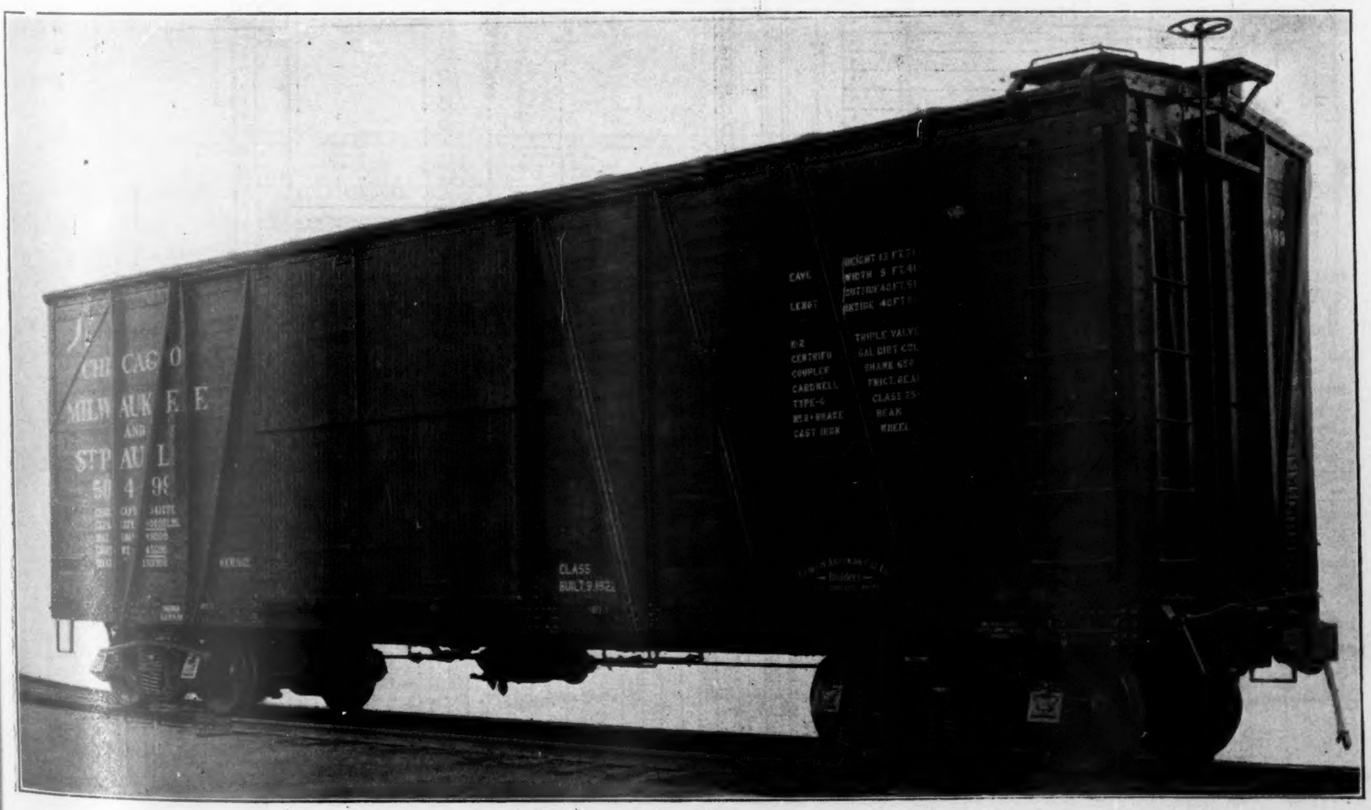


Chicago, Milwaukee & St. Paul Automobile Cars

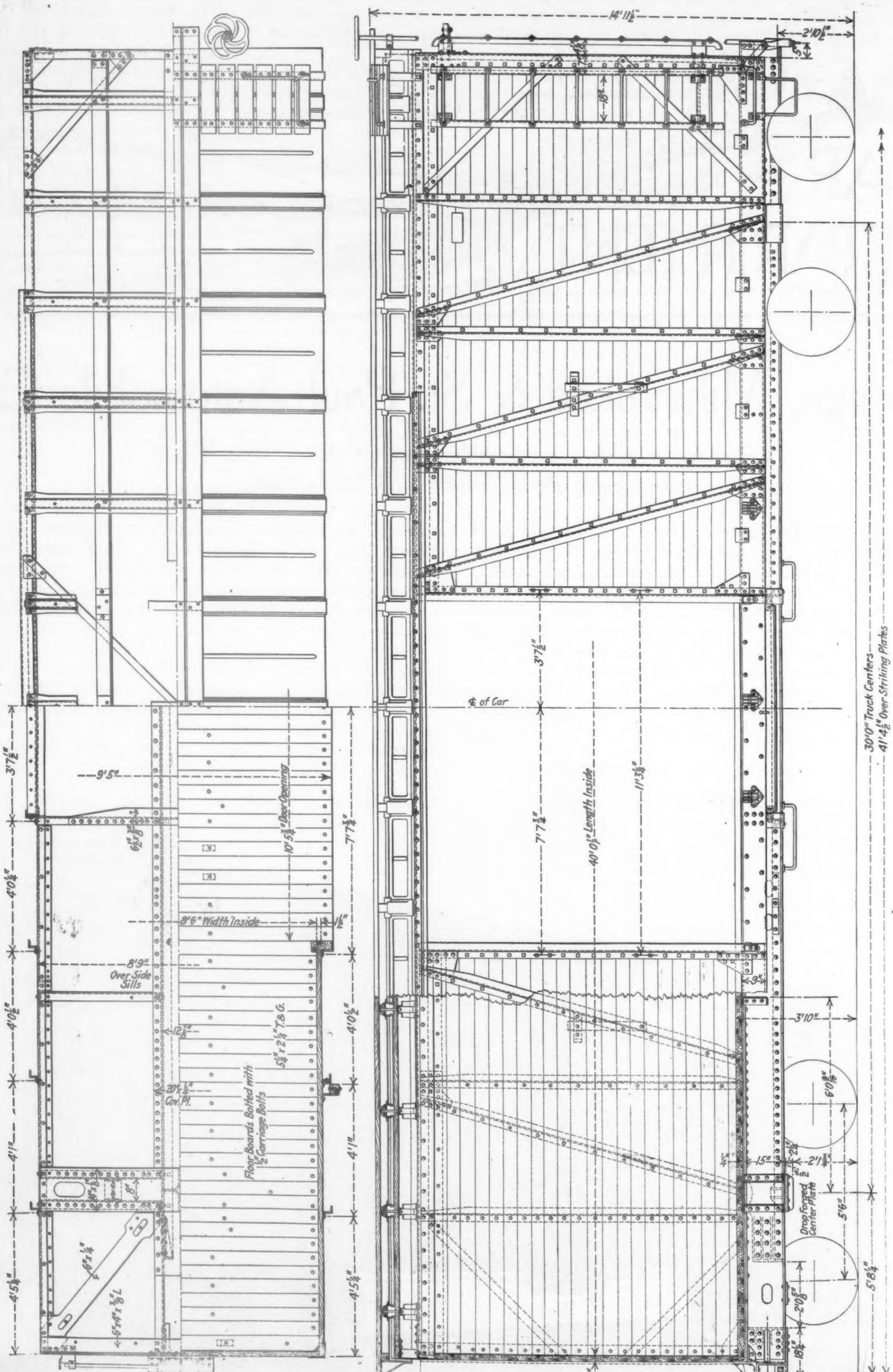
Calculations from the Specifications of Stresses in Truck Members, Body Frame and Underframe

DURING 1922 two orders aggregating 1,000 steel frame automobile cars were placed by the Chicago, Milwaukee & St. Paul with the General American Car Company. The first 500 cars are 40 ft. ½ in. and the others are 40 ft. 6 in. long inside. All are 8 ft. 6 in. wide and have a clear height of 10 ft. The door openings are 10 ft. wide by 9 ft. 8 in. high and are located unsymmetrically with respect to the transverse center line. The side frame trusses, which are interchangeable, are designed to carry the weight of the car body and lading and the center sills, which are of uniform section throughout, are designed to take the buffing stresses only.

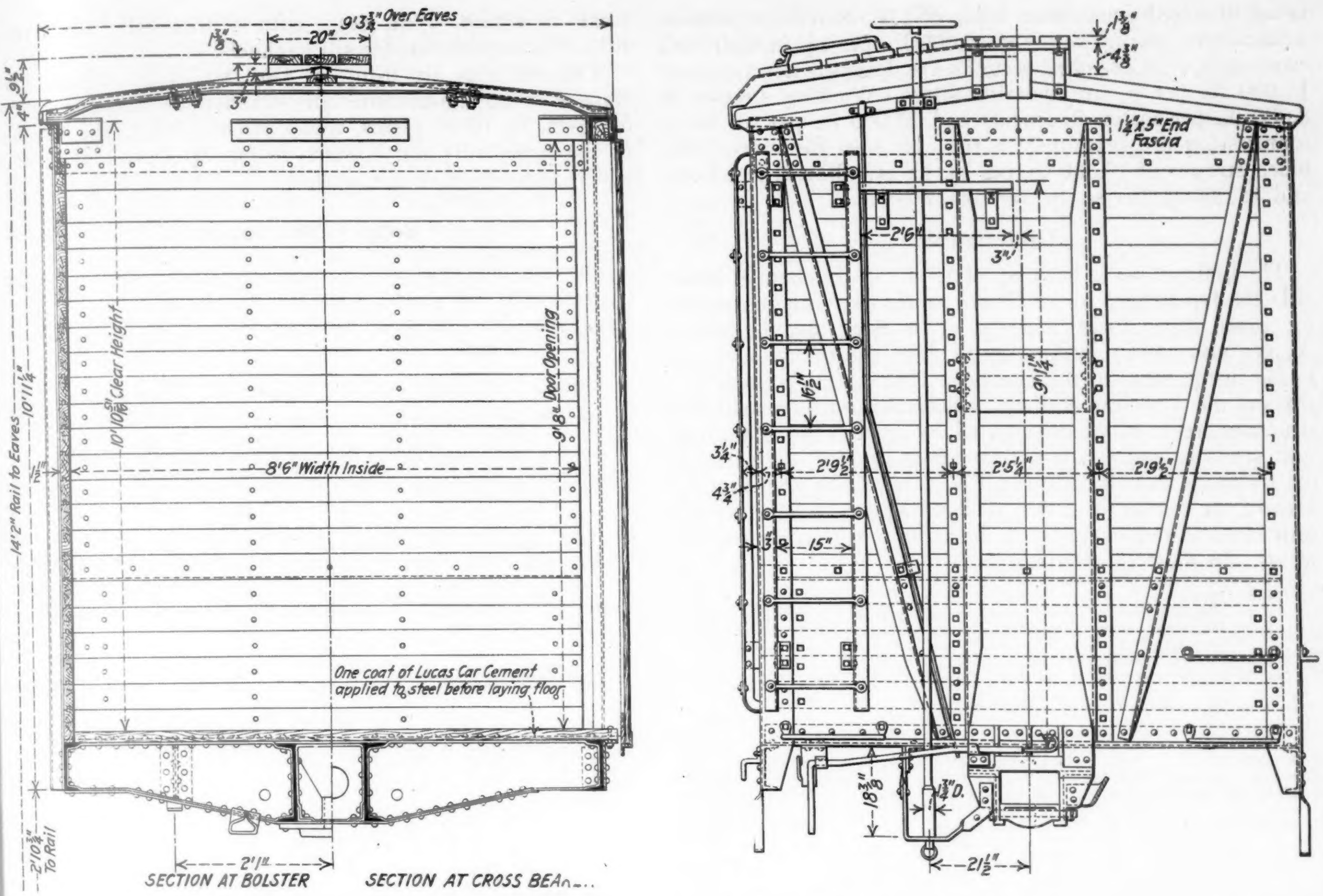
According to the practice adopted by the Chicago, Milwaukee & St. Paul, an engineering specification containing all basic data for the design and the stress calculations for all members subjected to definable loads, by which the sizes of these members are determined or checked, forms a part of the complete specifications for the equipment. In this specification the maximum unit stress for structural steel is 16,000 lb. per sq. in. For tension members this applies to the net section while for compression members it applies to the gross section. In the case of compression members and the compression flanges of members subjected to bending, the above unit stress is reduced by 70 times the ratio of the length of the member to the distance from the center of gravity of the section to the most stressed fibre. This ratio



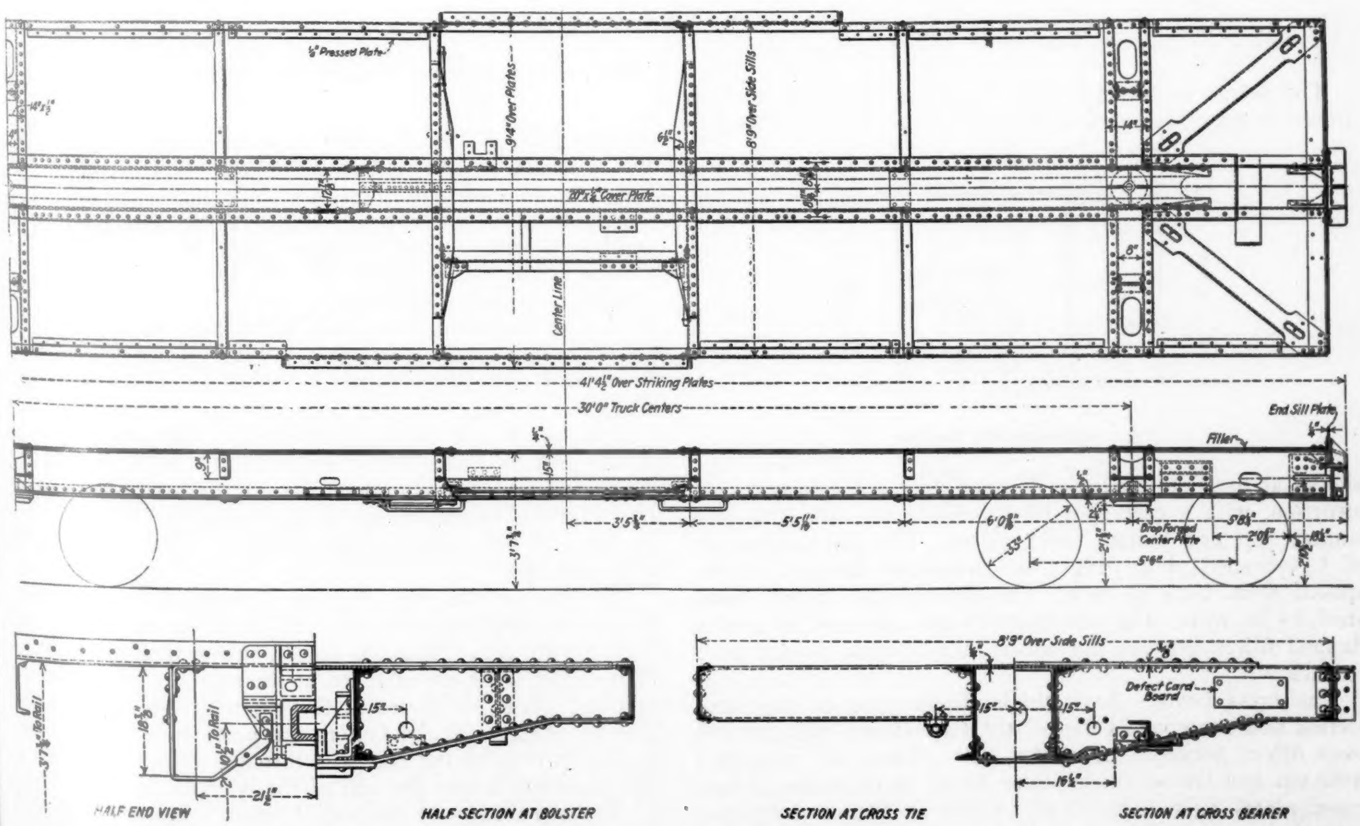
Steel Frame, Single Sheathed Automobile Box Car, Built for the C. M. & St. P. by the General American Car Company



Plan and Elevation of C. M. & St. P. Automobile Car



End Elevation and Cross Sections of Body of C. M. & St. P. Automobile Car



Plan, Side Elevation and Cross Sections of Underframe

is not to exceed a maximum value of 120. Rivets are allowed a maximum bearing value of 20,000 lb. per sq. in. and both rivets and webs of rolled sections are designed not to exceed 10,000 lb. per sq. in. shearing stress. Working stresses of 8,000 lb. per sq. in. in tension and 12,000 lb. per sq. in. in compression are permitted in the cast steel members; combined stresses of 10,000 lb. per sq. in. are allowed in tension and 15,000 lb. per sq. in. for compression.

Underframe

The underframe is built up of 15-in. 33-lb. channel center sills the top flanges of which are reinforced with continuous top cover plates 20 in. wide by 1/4 in. thick and the bottom flanges with 3 1/2-in. by 3-in. by 5/16-in. chord angles, riveted to the inside faces of the channels. The latest recommendations of the American Railway Association for center sill construction are a minimum area of 28 sq. in. and a ratio of unit stress to end strain not to exceed .05 for box cars. In the following calculations and Fig. 1 it will be seen that the area of the combined section is 28.66 sq. in. and the ratio of unit stress to end strain is .05, bringing it within the requirements. In these calculations let:

A = Area.
x = Distance base to center gravity each section.
d = Distance center of gravity of each section to neutral axis of the combined section.
S_t = Section modulus of top.
S_b = Section modulus of bottom.
$\frac{U.S.}{E.S.}$ = Ratio of unit stress to end strain.

	A		x		Ax	d	Ad²	Iz
Top plate	5.00	×	15.125	=	75.63	7.145	255.00	.03
Channels	19.8	×	7.5	=	148.50	48	4.58	625.20
Angles	3.86	×	1.06	=	4.10	6.92	184.00	4.66
	28.66				228.23		443.58	629.89
								443.58
								1,073.47

$$\frac{228.23}{28.66} = 7.98$$

$$S_t = \frac{1,073.47}{7.27} = 147.7$$

$$S_b = \frac{1,073.47}{7.98} = 134.5$$

$$\text{Ratio } \frac{U.S.}{E.S.} = \frac{1}{A} + \frac{E_c}{S_b} = \frac{1}{28.66} + \frac{1.98}{134.5} = .035 + .015 = .05$$

The bolster is designed to transmit the load from the side frame to the center plate and to resist the stresses set up by

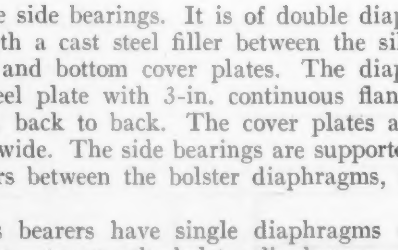


Fig. 1—Center Sill Section

shocks at the side bearings. It is of double diaphragm construction, with a cast steel filler between the sills and continuous top and bottom cover plates. The diaphragms are of 1/4-in. steel plate with 3-in. continuous flanges and are spaced 8 in. back to back. The cover plates are of 1/2-in. steel, 14 in. wide. The side bearings are supported by double flanged fillers between the bolster diaphragms, riveted back to back.

The cross bearers have single diaphragms of the same section and countour as the bolster diaphragms, with pressed steel fillers between the center sills. They are completed with top and bottom cover plates 3/8 in. in thickness. These cover plates have a maximum width of 6 1/2 in., tapering toward the end to the width of the diaphragm flanges. The cross ties are single diaphragms of 1/4-in. pressed steel, uniform in section, 9 in. deep, with neither cover plates nor fillers between the center sill channels.

The end sills are 6-in. by 4-in. by 3/8-in. angles. The corners of the underframe are stiffened by diagonal braces of 1/4-in. by 10-in. plates, which extend back to the junction of the center sills and bolsters, to the top flanges of both of which members they are riveted.

Body Construction

The side frames are unsymmetrical but interchangeable trusses, with 4-ft. panel spacing on both sides of the doorway. The side plates are built up of a 1/4-in. plate, 8 3/4 in. deep, with 4-in. by 3-in. by 5/16-in. angle flanges at the top. The truss posts and diagonals are Z bar sections. The 9-in. channel side sill forms the bottom chord of the truss. The door panel top chord consists of the side plate angle, reinforced with a supplementary angle of the same section riveted to the top flange of the side plate angle to form an inverted channel. The bottom chord of the door panel is formed by reinforcing the side sill with a 9-in. by 3 1/2-in. angle pressed from 1/2-in. plate. With the exception of the door posts, which are 4-in., 8.2-lb. Z bars, the posts and diagonals are all 3-in. sections, but varying in weight from 11.5 lb. per ft. for the diagonal member extending from the bolster post to the adjoining intermediate post, to 8.5 lb. for the third diagonals and the bolster and intermediate posts. The second diagonals from the bolsters have a weight of 9.8 lb. per ft. The corner posts are 6-in. by 6-in. by 3/8-in. angle sections.

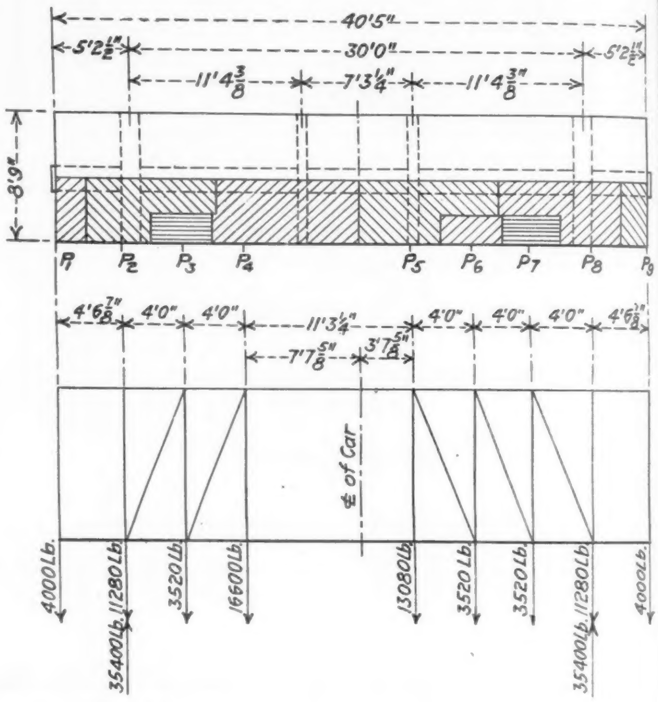


Fig. 2—Truss Loading Diagram for Uniformly Distributed Load

The ends of the car body are of composite construction. The frame members are 6-in., 15.7-lb. Z-bar end posts, and 3-in., 6.7-lb. Z-bar diagonal braces. These members and the angle corner posts are attached at the top to a 1/4-in. pressed steel end plate, reinforced at the top with 4-in. by 3-in. by 5/16-in. angles. At the bottom the posts and diagonals are secured directly to the end sills through a 1/4-in. web plate, which extends across the end of the car to a height of 32 3/4 in. The top corners of the body frame are braced diagonally by a 2 1/2-in. by 3/8-in. steel bar secured to the end and side plates with gussets.

The roof frame consists of pressed steel carlines of flanged channel sections, the contour of which provides for the location of the ridge pole above the carline and the purlines below the carline. The roof is of flexible steel construction. In addition to the bracing at the corners of the car, diagonal braces of 2½-in. by ¼-in. steel plates are applied across the car, intersecting at the center. These braces are secured to the side plates by gussets and at the point of intersection are secured to the tension member of the carline. This carline is trussed with a 3-in. by ¼-in. pressed channel tension member, with a U-shaped strut of 2½-in. by ⅝-in. material

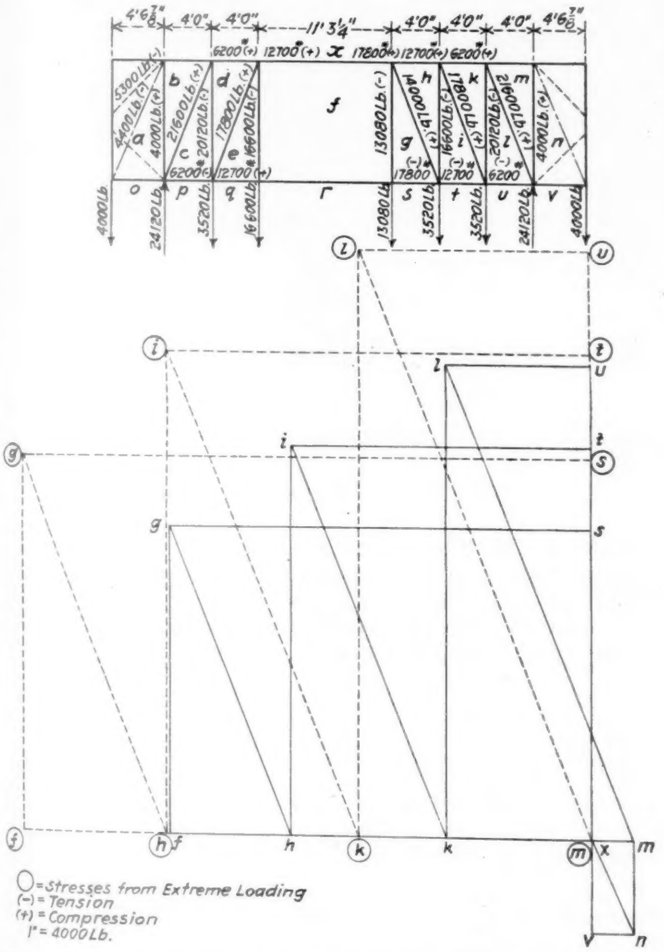


Fig. 3—Graphic Determination of Total Stresses in Truss Members

at the center, the flanges of which are riveted to the carline. The diagonals are riveted to the tension member of the strut.

The floor and sheathing are of tongued and grooved fir. The floor and end sheathing are of 2¼-in. material and the side sheathing of 1½-in. material.

In calculating the stresses of the body frame, 44,000 lb. are allowed for the weight of the car, from which is deducted an estimated weight of 14,000 lb. for the trucks. Adding 88,000, the nominal capacity plus 10 per cent overload, the gross weight of the loaded car amounts to 132,000 lb., which is the maximum for four 5-in. by 9-in. axles. After deducting the weight of the truck and adding 20 per cent of the remaining gross weight as an allowance for the effect of oscillation, the total load for which the body frame is designed is 141,600 lb. By referring to the dimensions on Fig. 2, it will be seen that the floor area of the car is 354 sq. ft., giving a uniformly distributed load of 400 lb. per sq. ft. On each side of the car this load is carried one-half directly by the side frame and the other half by the center sill. The latter load is in part carried across to the side frame by the cross bearers and in part delivered directly to the center plates at the bolsters. The total loads on one side of the car are as follows:

Panel (1) 2 ft. 3 7/16 in. × 4 ft. 4½ in. = 10.00, × 400 = 4,000 lb.
Panel (2) 8 ft 7¼ in. × 2 ft. 2¼ in. +
4 ft. 3 7/16 in. × 2 ft. 2¼ in. = 28.20, × 400 = 11,280 lb.
Panel (3) 4 ft. 0 in. × 2 ft. 2¼ in. = 8.80, × 400 = 3,520 lb.
Panel (4) 9 ft. 7⅝ in. × 2 ft. 2¼ in. +
9 ft 3 13/16 in. × 2 ft. 2¼ in. = 41.5, × 400 = 16,600 lb.
Panel (5) 5 ft. 7⅝ in. × 2 ft. 2¼ in. +
9 ft. 3 13/16 in. × 2 ft. 2¼ in. = 32.7, × 400 = 13,080 lb.
Panel (6) 4 ft. 0 in. × 2 ft. 2¼ in. = 8.80, × 400 = 3,520 lb.
Panel (7) 4 ft. 0 in. × 2 ft. 2¼ in. = 8.80, × 400 = 3,520 lb.
Panel (8) 8 ft. 7¼ in. × 2 ft. 2¼ in. +
4 ft. 3 7/16 in. × 2 ft. 2¼ in. = 28.20, × 400 = 11,280 lb.
Panel (9) 2 ft. 3 7/16 in. × 4 ft. 4½ in. = 10.00, × 400 = 4,000 lb.

Total on one side 70,800 lb.

Using these loads, the stresses in the truss members are determined graphically as shown in Fig. 3. In this diagram the vertical loads are laid out on a vertical line starting at "x" and ending at "x," proceeding according to the direction in which the force acts. These stresses may be determined either by the graphical method or by calculation. Referring to Fig. 3 and Fig. 4, the calculations may be made systematically in the following manner:

Stresses in Top and Bottom Chords

Moment at "fg"

24,120 × 3 × 4 ft. 0 in. = ... 289,440 ft. lb.
3,520 × 4 ft. 0 in. = ... 14,080 ft. lb.
3,520 × 2 × 4 ft. 0 in. = ... 28,160 ft lb.
4,000 × (3 × 4 ft. 0 in. + 4 ft. 6⅞ in.) = 66,280 ft. lb 108,520 ft. lb.

180,920 ft. lb.

$$\frac{180{,}920}{10.28} = 17{,}600 \text{ lb.}$$

Moment at "ef" or "hi"

24,120 × 2 × 4 ft. 0 in. = ... 192,960 ft. lb.
3,520 × 4 ft. 0 in. = ... 14,080 ft. lb.
4,000 × (2 × 4 ft. 0 in. + 4 ft. 6⅞ in.) = 50,280 ft. lb. 64,360 ft. lb.

128,600 ft. lb.

$$\frac{128{,}600}{10.28} = 12{,}500 \text{ lb.}$$

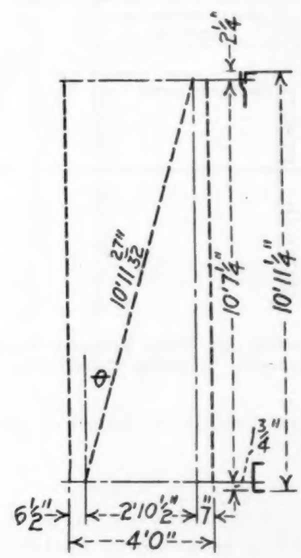


Fig. 4—Angle of the Truss Diagonals

Moment at "cd" or "kl"

24,120 × 4 ft. 0 in. = ... 96,480 ft. lb.
4,000 × 8 ft. 6⅞ in.= .... 34,280 ft. lb.

62,200 ft. lb.

$$\frac{62{,}200}{10.28} = 6{,}050 \text{ lb.}$$

Moment at "ab" or "mn"

$$\frac{4{,}000 \times 4 \text{ ft. } 6\tfrac{7}{8} \text{ in}}{10.28}$$ .... 1,780 lb.

Loads on Posts

"ab" and "mn" = ... 2,000 lb.
(One-half of end panel load carried to center plate by center sills)
"cd" and "kl" = ... 20,120 lb
"ef" and "hi" = ... 16,600 lb.
"fg" = ... 13,080 lb.

STRESSES IN DIAGONALS

$$\text{Sec. } \theta = \frac{10 \text{ ft. } 11\text{-}27/32 \text{ in.}}{10 \text{ ft. } 7\tfrac{1}{4} \text{ in.}} = \ldots\ldots 1.0361$$

Stresses in "bc" or "lm"
20,120 × 1.0361 = ... 20,900 lb.

Stresses in "cd" or "ik"
16,600 × 1.0361 = ... 17,200 lb.

Stress in "gh"
13,080 × 1.0361 = ... 13,600 lb.

The preceding calculations are based on a uniformly distributed load. With some kinds of grain it is conceivable that under certain conditions there might be a concentration of load toward the center with a corresponding diminution toward the ends. A rough analysis of such a possible condition led to the assumption that if the loadings at panel points P_2, P_3 and P_4, as shown in Fig. 5, are increased by 25 per cent, the stresses produced will be as severe as may be expected from any lading in a car of this type. The panel loads and resulting stresses in the truss members, obtained in this manner, are shown in Fig. 5.

In checking the strength of side frame members another condition must also be taken into account. A load of wheat will create a lateral bending moment in the side of the car and the side posts and braces must withstand this in addition to the stresses of tension or compression imposed on them by the vertical load. The amount of this bending moment is approximated by the application of Rankine's formula for retaining walls and assuming that the maximum bending moment coincides with the point at which the resultant of the side pressure is applied, at one-third of the height of the load above the car floor. In the latest revision of the specifications, on the basis of these assumptions, the bending moment per foot of car length is determined as follows (see Fig. 6):

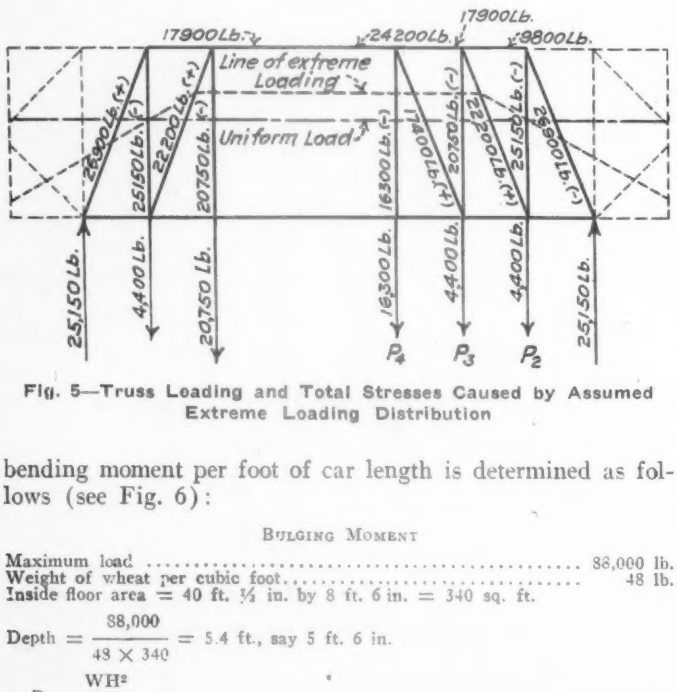


Fig. 5—Truss Loading and Total Stresses Caused by Assumed Extreme Loading Distribution

BULGING MOMENT

Maximum load .... 88,000 lb.
Weight of wheat per cubic foot .... 48 lb.
Inside floor area = 40 ft. ½ in. by 8 ft. 6 in. = 340 sq. ft.

$$\text{Depth} = \frac{88{,}000}{48 \times 340} = 5.4 \text{ ft., say 5 ft. 6 in.}$$

$$P = \frac{WH^2}{2}$$

Φ = angle of repose of load = 30 deg.

$$W = 48 \times \tan.^2\left(45 \text{ deg.} - \frac{\Phi}{2}\right)$$

$W = 48 \times 0.333 = 16$
$H = 5$ ft. 6 in.

$$P_1 = \frac{16 \times (5 \text{ ft. } 6 \text{ in})^2}{2} = 242 \text{ lb.}$$

$$R_2 = \frac{242 \times 2 \text{ ft. } 4\tfrac{3}{4} \text{ in.}}{10 \text{ ft. } 3\tfrac{3}{8} \text{ in.}} = 57 \text{ lb.}$$

$$P_2 = \frac{20 \times (3 \text{ ft. } 8 \text{ in.})^2}{2} = 107 \text{ lb.}$$

BM = 73 × 7 ft. 10⅝ in. = 449 ft. lb.
134 × (3 ft. 8 in. ÷ 3) = 131 ft. lb.
318 ft. lb.
× 12 = 3,816 in. lb.
20 per cent for oscillation 763
4579 say 4,600 in. lb.

For extreme loading conditions:
add 25 per cent 1150
5750 in. lb. per ft. of car length.

With the direct load and the bending moments caused by the bulging action of the lading established, the proposed

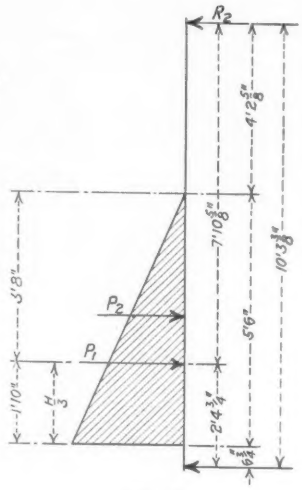


Fig. 6

sections of the truss members are checked for strength to withstand the combined stresses. These calculations, which follow, are made both on the basis of normal loading conditions and the extreme loading conditions assumed to be caused by heaping the lading toward the center of the car.

UNIT STRESS CALCULATIONS

Vertical "ab" and "mn"
Direct load = ... 2,000 lb. (+)
Bulging moment = 4,600 × 3 = ... 13,800 in. lb.
Proposed section: 3-in. 8.5-lb. Z.

$$A = 2.48;\ r = 1.21;\ SM = 2.4;\ L = 108;\ \frac{L}{r} = \frac{108}{1.21} = 84.7$$

$$16{,}000 - 70\frac{L}{r} = 10{,}170 \text{ lb.}$$

$$\text{Direct stress} = \frac{2{,}000}{2.48} = 810 \text{ lb per sq. in.}$$

$$\text{Bulging stress} = \frac{13{,}800}{2.4} = 5{,}750 \text{ lb. per sq. in.} \ldots\ldots 6{,}560 \text{ lb. per sq. in.}$$

Extreme loading (add 50 per cent to normal loading) = 9,840 lb. per sq. in.

Diagonal "bc" and "lm"
Direct load = ... 21,600 lb. (+)
Bulging moment = 4,600 × 2 = ... 9,200 in. lb.
Proposed section: 3-in. 11.5-lb. Z.

$$A = 3.36;\ r = 1.17;\ SM = 3.0;\ L = 107;\ \frac{L}{r} = \frac{107}{1.17} = 91.5$$

$$16{,}000 - 70\frac{L}{r} = 9{,}615 \text{ lb.; adding 20 per cent for combined stresses,} = 11{,}540 \text{ lb. per sq. in.}$$

$$\text{Direct stress} = \frac{21{,}600}{3.36} = 6{,}420 \text{ lb. per sq. in.}$$

$$\text{Bulging stress} = \frac{9{,}200}{3.0} = 3{,}060 \text{ lb. per sq. in.} \ldots\ldots 9{,}480 \text{ lb. per sq. in.}$$

Extreme loading:

$$\text{Direct stress} = \frac{26{,}900}{3.36} = \ldots\ldots 8{,}000 \text{ lb. per sq. in.}$$

$$\text{Bulging stress} = \frac{5{,}750 \times 2}{3.0} = 3{,}800 \text{ lb. per sq. in.} \ldots\ldots 11{,}800 \text{ lb. per sq. in.}$$

Vertical "cd" and "kl"
Direct load .... 20,120 lb. (—)
Bulging moment 6,500 × 2 = ... 13,000 in. lb.
Proposed section = 3-in. 8.5-lb. Z
Gross area = 2.48; SM = 2.4

Deduct .25 for one $\frac{13}{16}$-in. by $\frac{5}{16}$-in. hole, net area = 2.23

$$\text{Direct stress} = \frac{20{,}120}{2.23} = 9{,}000 \text{ lb. per sq. in.}$$

$$\text{Bulging stress} = \frac{9{,}200}{2.4} = 3{,}830 \text{ lb. per sq. in.} \ldots\ldots\ 12{,}830 \text{ lb. per sq. in.}$$

Extreme loading:

$$\text{Direct stress} = \frac{25{,}150}{2.23} = 11{,}260 \text{ lb. per sq. in}$$

$$\text{Bulging stress} = \frac{5{,}750 \times 2}{2.4} = 4{,}790 \text{ lb. per sq. in.} \ldots\ 16{,}050 \text{ lb. per sq. in.}$$

Diagonal "de" and "ik"

Direct load = ... 17,800 lb. (+)
Bulging moment = 4,600 × 2 = ... 9,200 in. lb.
Proposed section = 3-in. 9.8-in. Z.

$$A = 2.86;\ r = 1.16;\ SM = 2.6;\ L = 107;\ \frac{L}{r} = \frac{107}{1.16} = 92.2$$

$$16{,}000 - 70\frac{L}{r} = 9{,}550 \text{ lb.; adding 20 per cent for combined stresses} = 11{,}460 \text{ lb. per sq. in.}$$

$$\text{Direct stress} = \frac{17{,}800}{2.86} = \ldots 6{,}230 \text{ lb. per sq. in.}$$

$$\text{Bulging stress} = \frac{9{,}200}{2.6} = 3{,}540 \text{ lb. per sq. in.} \ldots\ldots\ 9{,}770 \text{ lb. per sq. in.}$$

Extreme loading:

$$\text{Direct stress} = \frac{22{,}260}{2.86} = \ldots\ 7{,}790 \text{ lb. per sq. in.}$$

$$\text{Bulging stress} = \frac{5{,}750 \times 2}{2.6} = 4{,}420 \text{ lb. per sq. in.} \ldots\ldots\ 12{,}210 \text{ lb. per sq. in.}$$

Vertical "ef" Door Post

Direct load = ... 16,600 lb. (—)
Bulging moment = 4,600 × 3 ft. 7½ in. = ... 16,680 in. lb.
Proposed section = 4-in., 8.2-in. Z.
Gross area = 2.41; SM = 3.1
Deduct .21 for one $\frac{13}{16}$-in. by ¼-in. hole; net area = 2.20

$$\text{Direct stress} = \frac{16{,}600}{2.20} = 7{,}550 \text{ lb. per sq. in.}$$

$$\text{Bulging stress} = \frac{16{,}680}{3.1} = 5{,}380 \text{ lb. per sq. in.} \ldots\ldots\ldots\ 12{,}930 \text{ lb. per sq. in.}$$

Extreme loading:

$$\text{Direct stress} = \frac{20{,}750}{2.20} = \ldots\ldots\ 9{,}430 \text{ lb. per sq. in.}$$

$$\text{Bulging stress} = \frac{5{,}750 \times 3.625}{3.1} = 6{,}730 \text{ lb. per sq. in.} \ldots 16{,}160 \text{ lb. per sq. in.}$$

Camel Company's sliding door post

Bulging moment = 5,750 × 5-ft. 7½. = ... 32,350 in. lb.

$$\text{Minimum section modulus for steel} = \frac{32{,}350}{16{,}000} = 2.02.$$

Vertical "fg"-Door Post

Direct load = ... 13,080 lb. (—)
Bulging moment = 4,600 × 4-ft. 6-in. = ... 20,700 in. lb.
Proposed section = 4-in. 8.2-lb. Z.
Gross area = 2.41; SM, = 3.1
Deduct .21 for one $\frac{13}{16}$-in. by ¼-in. hole, net area = 2.20

$$\text{Direct stress} = \frac{13{,}080}{2.20} = 5{,}950 \text{ lb. per sq. in.}$$

$$\text{Bulging stress} = \frac{20{,}700}{3.1} = 6{,}680 \text{ lb. per sq. in.} \ldots\ldots\ldots\ 12{,}630 \text{ lb. per sq. in.}$$

Extreme loading:

$$\text{Direct stress} = \frac{16{,}300}{2.20} = \ldots\ 7{,}420 \text{ lb. per sq. in.}$$

$$\text{Bulging stress} = \frac{5{,}750 \times 4.5}{3.1} = 8{,}350 \text{ lb. per sq. in.} \ldots\ldots\ 15{,}750 \text{ lb. per sq. in.}$$

Diagonal "gh"

Direct load = ... 13,600 lb. (+)
Bulging moment = 4,600 × 2 = ... 9,200 in. lb.
Proposed section = 3-in. 8.5-lb. Z.

$$A = 2.48;\ r = 1.21;\ SM = 2.4;\ L = 107;\ \frac{L}{r} = \frac{107}{1.21} = 88.4$$

$$16{,}000 - 70\frac{L}{r} = 9{,}800 \text{ lb.; adding 20 per cent for combined stresses} = 11{,}760 \text{ lb.}$$

$$\text{Direct stress} = \frac{13{,}600}{2.48} = 5{,}480 \text{ lb. per sq. in.}$$

$$\text{Bulging stress} = \frac{9{,}200}{2.4} = 3{,}830 \text{ lb per sq. in.} \ldots\ldots\ldots\ 9{,}310 \text{ lb. per sq. in.}$$

Extreme loading:

$$\text{Direct stress} = \frac{17{,}400}{2.48} = 7{,}020 \text{ lb. per sq. in.}$$

$$\text{Bulging stress} = \frac{5{,}750 \times 2}{2.4} = 4{,}780 \text{ lb. per sq. in.} \ldots\ldots\ 11{,}800 \text{ lb. per sq. in.}$$

Vertical "hi"

Direct load = ... 16,600 lb. (—)
Bulging moment = 4,600 × 2 = ... 9,200 in. lb.
Proposed section = 3-in. 8.5-lb. Z.
Gross area = 2.48; SM = 2.4
Deduct .25 for one $\frac{13}{16}$-in. by $\frac{5}{16}$-in. hole, net area = 2.23

$$\text{Direct stress} = \frac{16{,}600}{2.23} = 7{,}450 \text{ lb. per sq. in.}$$

$$\text{Bulging stress} = \frac{9{,}200}{2.4} = 3{,}830 \text{ lb. per sq. in.} \ldots\ldots\ldots\ 11{,}280 \text{ lb. per sq. in.}$$

Extreme loading:

$$\text{Direct stress} = \frac{20{,}750}{2.23} = \ldots\ 9{,}300 \text{ lb. per sq. in.}$$

$$\text{Bulging stress} = \frac{5{,}750 \times 2}{2.4} = 4{,}790 \text{ lb. per sq. in.} \ldots\ldots\ 14{,}090 \text{ lb. per sq. in.}$$

Top Chord

Maximum stress = ... 17,800 lb. (+)
Effective area at door = 4 in. by 3 in. by $\frac{5}{16}$ in. side plate angle = ... 2.09
4 in. by 2½ in. by $\frac{5}{16}$ in. door angle = ... 2.00
4.09

$$\text{Stress} = \frac{17{,}800}{4.09} \ldots\ldots\ldots\ldots\ 4{,}360 \text{ lb. per sq. in.}$$

$$\text{Extreme loading stress} = \frac{24{,}200}{4.09} \ldots\ldots\ldots\ 5{,}920 \text{ lb. per sq. in.}$$

Bottom Chord

Maximum chord load = ... 17,800 lb. (—)
Proposed section = 9-in. 13.4-lb. channel.
Gross area = 3.89
Deduct 0.96 for two holes in flanges and three in web, net area = 2.93

$$\text{Stress in at right cross bearer} = \frac{17{,}800}{2.93} = \ldots\ldots\ldots\ 6{,}070 \text{ lb. per sq. in.}$$

Loading across the doorway:
Chord load = ... 17,800 lb. (—)
Uniformly distributed load = W = 11 ft. 3½ in. × 2 ft. 2¼ in. × 400 = 9,890 lb.
Load concentrated at left crossbearer = W^1 = 9 ft. 3$\frac{13}{16}$ in. × 2 ft. 2¼ in. × 400 = 8.170 lb.

$$\text{Maximum moment} = \left(W^1 + \frac{W}{2}\right)\frac{CC_1}{1}$$

C = distance from left door post to left cross bearer = ... 3.64 ft.
C_1 = distance from right door post to left cross bearer = ... 7.63 ft.
1 = door panel length = ... 11.27 ft.

$$\text{Maximum moment} = 12\left(8{,}170 + \frac{9{,}890}{2}\right)\frac{3.64 \times 7.63}{11.27} = \ldots\ 387{,}120 \text{ in. lb.}$$

Proposed section:

9-in. 13.4-lb. channel;	SM = 10.5; net area = ...	2.93
9-in. 25.2-lb. ship channel;	SM = 19.4; net area = 6.63—1.33 =	5.30
	29.9	8.23

$$\text{Chord stress} = \frac{17{,}800}{8.23} = 2{,}160 \text{ lb. per sq. in.}$$

$$\text{Bending stress} = \frac{387{,}120}{29.9} = 12{,}930 \text{ lb. per sq. in.} \ldots\ldots\ 15{,}090 \text{ lb. per sq. in.}$$

Trucks

The cars are equipped with Bettendorf trucks with U-section cast steel side frames and integral journal boxes. Completely equipped, each truck weighs 7,128 lb., of which the side frames account for 1,125 lb. and the bolster 818 lb. The details of the weight distribution are shown in a table.

Fig. 7 is a sketch of the side frame showing the loads to which it is subjected and the properties of the sections of the side frame members. The vertical load on the side frame is based on the assumption that it must withstand an increase of 50 per cent in the truck load distribution over the normal axle capacity. The maximum transverse load is assumed to be 40 per cent of the normal vertical load. The method of external moments is used in determining the stresses caused by the vertical loading. In these calculations a moment arm equal to the distance from the journal center to the adjacent spring seat has been used throughout. This is longer than that used by some engineers, who assume that the effective

moment arm is equal to the horizontal distance from the journal center to the axis of the truck column. The stresses determined by the longer arm are about 18 per cent greater than those determined by the other method. In these specifications, however, combined stresses are permitted to exceed

Actual Weights of 40-Ton Truck Parts

	Weight Lbs.
4 5-in. by 9-in. wedges	59.5
4 5-in. by 9-in. brasses	80
2 Nests of truck springs	206
4 Brake shoe keys	4
4 Brake shoes	76.5
2 Brake beams	189.5
2 Side bearings	29.5
2 Side bearing filler blocks	19
1 Tie bar	125
2 Brake beam safety bars	31
2 Spring caps	20
2 Oak spring fillers	9
2 Truck levers	47.5
1 Dead lever fulcrum bracket	5.5
1 Bottom rod	32
4 Dust guards	3
4 Brake beam hangers	30
4 Brake beam hanger pins	15.5
6 M. C. B. brake pins	5.5
4 Wheels	2,774
2 Axles	1,338
Waste	8
Oil	24
4 Asco lids and pins	23
Rivets and cotters	4
1 Truck bolster	818
2 Side frames	1,125
2 Side bearing fillers	26
	7,128
	2
One set of trucks	14,256

the usual maximum working stress by 20 per cent, so that there is little difference in the final result so far as the size of the members is concerned. The stresses on the various sections are determined as follows:

Unit Stresses in 40-Ton Truck Side Frame

Section A-A
Area = 6.6; Transverse SM = 10.54

$$\text{Transverse force at } R_2 = \frac{6{,}200 \times 14.70}{21.2} = \ldots\ldots\ 4{,}300 \text{ lb.}$$

Transverse force at R_1 = 6,200 — 4,300 = ... 1,900 lb.

$$\text{Transverse stress} = \frac{4.300 \times 25.58}{10.54} = \ldots\ldots\ 10{,}400 \text{ lb. per sq. in.}$$

$$\text{Vertical stress} = \frac{23{,}250 \times 30.2}{21.2 \times 6.6} = \ldots\ldots\ 5{,}000 \text{ lb. per sq. in.}$$

Total combined stress .... 15,400 lb. per sq. in.

Section B-B
Area = 12.37; Transverse SM = 36.79
Vertical SM = 10.85

$$\text{Transverse stress} = \frac{1{,}900 \times 25.58}{36.79} = \ldots\ldots\ 1{,}320 \text{ lb. per sq. in.}$$

$$\text{Vertical stress} = \frac{23{,}250 \times 30.2}{21.2 \times 12.37} = \ldots\ldots\ 2{,}680 \text{ lb. per sq. in.}$$

$$\text{Local stress} = \frac{23{,}250 \times 5.2}{2 \times 10.85} = \ldots\ldots\ 5{,}570 \text{ lb. per sq. in.}$$

Total combined stress .... 9,570 lb. per sq. in.

Section C-C
Area = 12.26; Transverse SM = 15.44
Vertical SM = 12.75

$$\text{Transverse stress} = \frac{1{,}900 \times 25.58}{15.44} = \ldots\ldots\ 3{,}150 \text{ lb. per sq. in.}$$

$$\text{Vertical stress} = \frac{23{,}250 \times 30.2}{21.2 \times 12.26} = \ldots\ldots\ 2{,}980 \text{ lb. per sq. in.}$$

$$\text{Local stress} = \frac{23{,}250 \times 4.45}{2 \times 12.75} = \ldots\ldots\ 4{,}050 \text{ lb. per sq. in.}$$

Total combined stress .... 10,180 lb. per sq. in.

Section D-D
Area = 6.45; Transverse SM = 7.72; Tan. 6 deg. 45 minutes = 0.118

$$\text{Transverse stress} = \frac{4{,}300 \times 6.5}{7.72} = \ldots\ldots\ 3{,}620 \text{ lb. per sq. in.}$$

$$\text{Vertical stress} = \frac{23{,}250 \times 30.2 \times 0.118}{21.2 \times 6.45} = \ldots\ldots\ 600 \text{ lb. per sq. in.}$$

Total combined stress .... 4,220 lb. per sq. in.

Section E-E
Area 5.64; Transverse SM = 8.06; Sec. 6 deg. 45 min. = 1.007

$$\text{Transverse stress} = \frac{4{,}300 \times 19}{8.06} = \ldots\ldots\ 10{,}130 \text{ lb. per sq. in.}$$

$$\text{Vertical stress} = \frac{23{,}250 \times 30.2 \times 1.007}{21.2 \times 5.64} = \ldots\ldots\ 5{,}900 \text{ lb. per sq. in.}$$

Total combined stress .... 16,030 lb. per sq. in.

Section F-F
Area 5.25 in.; Transverse SM = 6.31; Sec. 33 deg. 40 min. = 1.2015

$$\text{Transverse stress} = \frac{1{,}900 \times 16}{6.31} = \ldots\ldots\ 4{,}820 \text{ lb. per sq. in.}$$

$$\text{Vertical stress} = \frac{23{,}250 \times 30.2 \times 1.2015}{21.2 \times .525} = \ldots\ldots\ 7{,}600 \text{ lb. per sq. in.}$$

Total combined stress .... 12,420 lb. per sq. in.

In sections A-A and F-F the combined stresses are in excess of the allowable unit stress for cast steel. These sections are considered satisfactory, however, because the unit stresses caused by the vertical loading are low in section

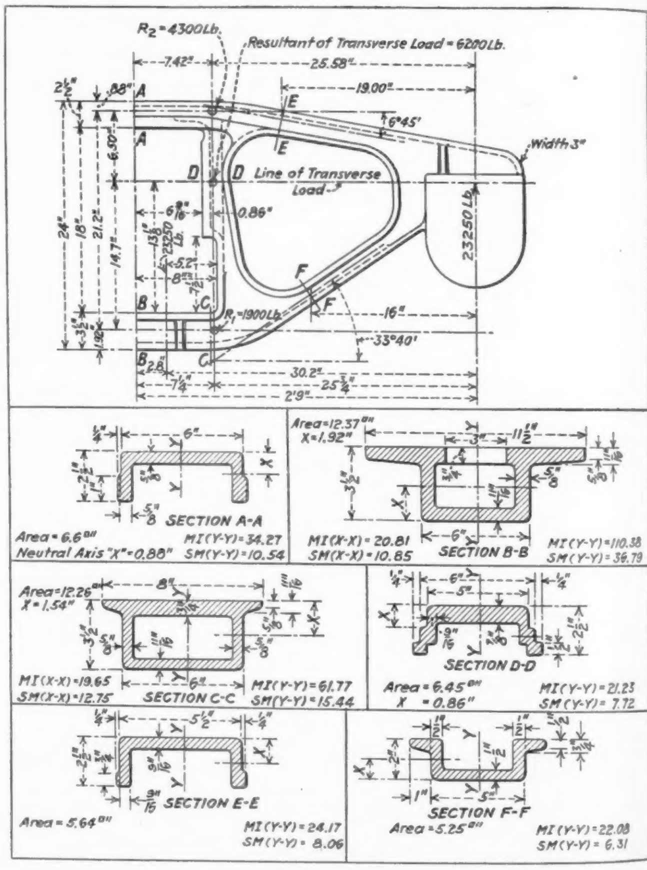


Fig. 7

A-A and the components are both low in section F-F. In the case of section D-D of the truck column, the combined stress is much below the allowable maximum. Here, however, the fact that the web member is subjected to wear, is the controlling factor in fixing a minimum thickness of 7/8 in.

Bolster

The bolster is of box section, a general outline of which is shown in Fig. 8. The stresses are checked at sections through the center, through the side bearing, at intermediate points 11½ in. and 20½ in. from the center and at a point 7 in. outside the side bearing. The loading conditions assumed and the stress calculations are shown herewith:

Loading

Total weight (A. R. A. maximum) at rail	132,000 lb.
Less two trucks	14,000 lb.
	118,000 lb.
Weight of two truck bolsters	1,640 lb.
	119,640 lb.

Load per each bolster 119,640 × ½ = ... 59,820
Add for oscillation 20 per cent..................... 11,964
71,784 say 72,000 lb.

Extreme loading = entire load on one side bearing
Horizontal load 0.4 × 72,000 = ... 28,800 lb.
Center of gravity of load and car body for automobile cars, from top of rail.. 6 ft.-10 in.
Distance from rail to resultant of horizontal force.............. 21⅛ in.
Distance from center line of horizontal force to center of gravity for car body and load = 6 ft. 10 in. — 1 ft. 9⅛ in. = ... 5 ft.⅞ in.

$$\text{Minimum distance from center to side bearing} = \frac{28,800}{72,000} \times 5 \text{ ft. } \tfrac{7}{8} \text{ in.} = 2 \text{ft. } \tfrac{3}{8} \text{ in}$$

Section at Center
Section Modulus, Tension = 119.00
Section Modulus, Compression = 161.00

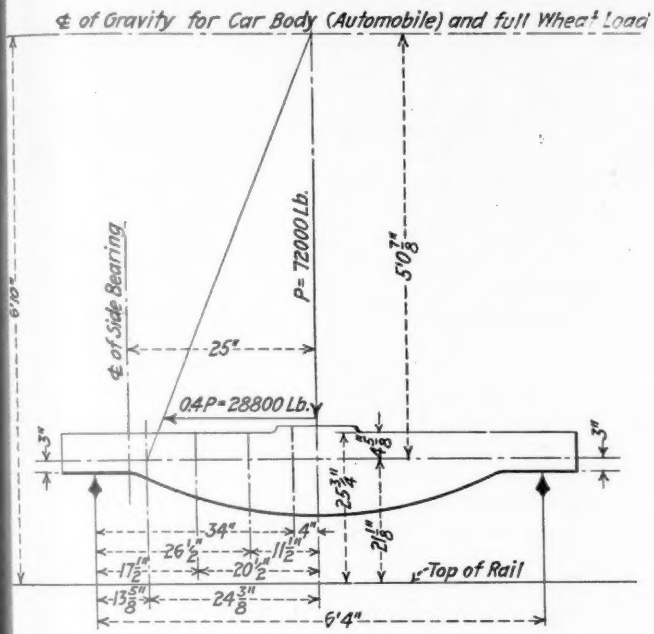


Fig. 8

$$\text{Tensile stress} = \frac{72,000 \times 38}{2 \times 119} = \ldots\ldots\ldots\ldots \text{ 11,500 lb. per sq. in.}$$

$$\text{Compression stress} = \frac{72,000 \times 38}{2 \times 161} = \ldots\ldots\ldots\ldots \text{ 8.500 lb. per sq. in.}$$

Section 11½ in. from Center of Bolster
SM Tension = 104.7
SM Compression = 92.1
Extreme loading:

$$R_1 = \frac{72,000 \times 63}{76} = 59,700 \text{ lb.}$$

R_2 = 72,000 — 59,700 = 12,300 lb.
B M = 49.5 × 12,300 = 610.000 in. lb.
Load concentrated at center:
BM = 36,000 × 26.5 = 954,000 in. lb.

Load on Side Bearing:

$$\text{Tensile stress} = \frac{610,000}{104.7} = \ldots\ldots\ldots\ldots \text{ 5,820 lb. per sq. in.}$$

$$\text{Compression stress} = \frac{610,000}{92.1} = \ldots\ldots\ldots\ldots \text{ 6,620 lb. per sq. in.}$$

Load on Center Plate:

$$\text{Tensile stress} = \frac{954,000}{104.7} = \ldots\ldots\ldots\ldots \text{ 9,100 lb. per sq. in.}$$

$$\text{Compression stress} = \frac{954,000}{92.1} = \ldots\ldots\ldots\ldots \text{ 10,350 lb. per sq. in.}$$

Section 20½ in. from Center to Bolster
SM Tension = 79.9
SM Compression = 72.4
Load on Side Bearing:

$$\text{Tensile stress} = \frac{12,300 \times 58.5}{79.9} = \ldots\ldots\ldots\ldots \text{ 9,020 lb. per sq. in.}$$

$$\text{Compression stress} = \frac{12,300 \times 58.5}{72.4} = \ldots\ldots\ldots\ldots \text{ 9,940 lb. per sq. in.}$$

Load on Center Plate:

$$\text{Tensile stress} = \frac{36,000 \times 17.5}{79.9} = \ldots\ldots\ldots\ldots \text{ 7,890 lb. per sq. in.}$$

$$\text{Compression stress} = \frac{36,000 \times 17.5}{72.4} = \ldots\ldots\ldots\ldots \text{ 8,710 lb. per sq. in.}$$

Section at Side Bearing
SM Tension = 65.1
SM Compression = 78.9
Load on side bearing:

$$\text{Tensile stress} = \frac{59,700 \times 13}{65.1} = \ldots\ldots\ldots\ldots \text{ 11,800 lb. per sq. in.}$$

$$\text{Compression stress} = \frac{59,700 \times 13}{78.9} = \ldots\ldots\ldots\ldots \text{ 9,850 lb. per sq. in.}$$

Load on Center Bearing:

$$\text{Tensile stress} = \frac{36,000 \times 13}{65.1} = \ldots\ldots\ldots\ldots \text{ 7,190 lb. per sq. in.}$$

$$\text{Compression stress} = \frac{36.000 \times 13}{78.9} = \ldots\ldots\ldots\ldots \text{ 5,930 lb. per sq. in.}$$

Section 32 in. from Center of Bolster
SM Tension = 50.9
SM Compression = 50.9
Load on Side Bearing:

$$\text{Tensile stress} = \frac{59,700 \times 6}{50.9} = \ldots\ldots\ldots\ldots \text{ 7,040 lb. per sq. in.}$$

$$\text{Compression stress} = \frac{59,700 \times 6}{50.9} = \ldots\ldots\ldots\ldots \text{ 7,040 lb. per sq. in.}$$

Load on Center Plate:

$$\text{Tensile stress} = \frac{36,000 \times 6}{50.9} = \ldots\ldots\ldots\ldots \text{ 4,240 lb. per sq. in.}$$

$$\text{Compression stress} = \frac{36,000 \times 6}{50.9} = \ldots\ldots\ldots\ldots \text{ 4,240 lb. per sq. in.}$$

As the extreme conditions, with the entire load on one side bearing, probably will never occur unless the car is turned over, these sections are considered satisfactory.

The Past and Present in Coal Cars on the Reading

Successful Lubrication of Journal Boxes*

Close Attention to Minor Defects Makes Delays; Does It in Fact Reduce or Increase Hot Boxes?

By W. J. O'Connor

THE preparation of boxes, journals and bearings should be handled as follows: All boxes should be thoroughly cleaned. Where new boxes are applied, great care should be exercised in seeing that all scale and sand are removed; this is easily accomplished by using compressed air. Close fitting dust guards should be applied in all cases when renewing wheels.

The preparation of journals for service is of the utmost importance. Where journals are finished on a lathe, the finishing cut should not exceed 1/16 in. in width. Where it is wider than this the cutting edge is so heavy that the roller will not produce a smooth finish. Furthermore, anything more than the ordinary friction heat on such journals automatically brings out these edges, and the result is a cut journal. With the finest cut possible, and the roller properly adjusted on the holder, this condition is practically eliminated. The roller should be oval-shaped so that the edges do not come in contact with the journal. It should also be placed on the holder in such a position that it burnishes slightly below the center of the journal. The trueing of journals by grinding is best done with a medium grade of wheel; the polishing is also best done with a medium grade of emery cloth.

The finishing of collars and fillets, no matter how the journal has been trued up, always produces more or less cutting edges on each end. The finishing of these parts is best accomplished by using a 1½-in. by 16-in. flat mill file, after which they are polished with a medium grade of emery cloth.

Experience tells us that, as a general rule, journal bearings do not fit properly on the journals when received from the manufacturer. In other words, the bearings have high spots, apparently caused by shrinkage in the lining metal. The unevenness of the lining in the bearing averages about 1/32 in. It is our practice to use a power-boring machine to fit these bearings to the journals, and so far the results we have received are more than gratifying.

When applying a brass to the journals, the surface of the bearing should be given a coating of oil. Never wipe the face of the brass or journal with oily waste. When trucks are assembled or removed for repairs, suitable lubrication must be applied to center plate and friction side bearings.

The journal bearing wedges, in my opinion, is the most important feature of the contained parts of journal boxes. A check was recently made of some 100 or more new journal bearings applied within a given period: 60 were renewed on account of cracked linings caused by the journal bearing wedge; 28 bearings were renewed because the wedge either of the hollow-back or solid-back type was worn flat.

We have had failures on fast trains where it was found that there was practically no crown on top of the wedge. The wedges had been continued in service until they were worn flat. It is, therefore, safe to assume that had these bearings had proper wedges, the failures might have been avoided.

My purpose in illustrating these cases is to call attention to the desirability of giving as much attention to the condition of the wedge as we do to the condition of the journal bearing when a change of brass is necessary. It has been our experience that the drop forged steel solid back wedge is the most serviceable.

Some of the causes of journal failures are as follows:

1.—Flat top wedges will take a permanent set on journal bearing, stopping the proper motion of the brass. Result: A cut journal in 25 miles.

2.—Lumps of babbitt metal on the back or sides of the brass prevent the wedge from having a correct fit on the journal bearing. Result: A hot box in 50 miles.

3.—Lining of journal bearing nicked and edges torn. Will pick up a waste grab. Result: A hot box in 10 miles.

4.—On heavy passenger cars equipped with a single brake, the extension on the side of the brass becomes worn and crushed after six months' service. This distorts the lining, causing it to be drawn out over the sides of the brass.

5.—Back end rolls too long. Result: The end of the roll catches under the bearing and starts a hot box.

6.—Boxes overpacked; the waste becomes glazed and will not lubricate.

7.—Journal box covers missing.

All large repair points and shops should have a special truck gang for the purpose of changing journal bearings, wheels, journal boxes and truck sides. Such men should be trained to see the importance of having the separate parts thoroughly cleaned and properly fitted when assembling. It has been found to be a rather difficult matter to train all repairmen to handle this kind of work as it should be done when they have other parts of the car to repair.

We should try, in all ways possible, to specialize on this class of work and endeavor to attract the oldest, most experienced and careful mechanics to follow it out. It is found at the present time, at the majority of shops and repair tracks that the changing of wheels is not the most desirable job.

The discontinuance of compensation for periodical repacking of journal boxes on foreign cars must have been for good reason, but I feel it should have remained one of the requirements of the rules, as much so as the periodical cleaning of air brakes.

While standard instructions for inspection of journal boxes in interchange on all railroads more or less bring out the method of handling a box when there is evidence of previous heating, still it is to be regretted that so many railroads find it necessary to disturb the packing, anticipating that there may be trouble. Over-zealousness is more detrimental to the service than beneficial. No box should be disturbed when the packing is in good condition, where there is no sign of recent heating either on the wheel plate or the face of the collar of the journal. This practice has been adopted as good railroading for a number of years, and we feel it is still good enough to be continued.

We maintain equipment largely at the expense of the owner on all necessary repairs at the present time, and there is no valid reason why the upkeep of the journal box packing and contained parts should not be in the same category. This is a most vital item for expediting the movement of freight. We all feel that our present means of lubrication will continue with us for some years to come. Such being

* This paper was read and discussed at the convention of the Chief Interchange Car Inspectors' and Car Foremen's Association of America, held at the Hotel Sherman, Chicago, November 9 and 10, 1922.

the case, let us all work together to bring it to the very highest standard.

Discussion

G. Lynch (Cleveland, Ohio): The writer of the paper speaks a great deal about the worn condition of the wedge in the box. Now, if the wedge is worn, the roof of the box should be also. What does Mr. O'Connor do with the box?

Mr. O'Connor: I find where this worn condition exists invariably you find the hollow back type of wedge. That is why I lay such stress on the drop forge wedge. Where a box is worn badly, it is removed, but this is not frequently. The drop forged solid back type will take care of a poor journal box sufficiently.

T. S. Cheadle (Richmond, Va.): There is one thing the paper did not bring out, and that is the question of the loose linings. A lining sometimes is loose because it does not stick as it should. One of the manufacturers with whose brasses we had a good deal of trouble told us if we would test the brass by ringing, it would show whether the lining was loose. We have followed that practice, not only on new brasses, but on the relined brasses. We do not have as many hot boxes where new brasses are applied as we had formerly.

Mr. O'Connor: It must be understood that the tinning will melt at a lesser degree than the lining. Where the tinning is not properly applied or the mixture is not correct, you will have loose linings.

C. J. Wymer (C. & E. I.): One cause of hot boxes is lack of the use of the packing iron. We have men out in the yard to go over the boxes, but in practice they merely lift the lid and snap it down. The proper use of the packing iron in the train yards, getting the packing properly adjusted in the journal will eliminate a lot of hot boxes.

During the recent trouble, we were bothered with hot boxes on passenger trains, and we took some men, who had no experience in the packing of boxes, and showed them how to take care of them. The result was that we scarcely had a hot box on passenger trains while these men were looking after them.

G. P. Zachritz (M. St. P. & S. S. M.): We are told that our journals must be right, our brasses must be right, our boxes must be right, and all conditions must be right. On a road in the northwest all these things were right and yet there was at one time a lot of hot boxes. Men were sent out to ride passenger trains and it seemed impossible to locate the trouble. But when it was finally located, they found they were using a waste that threw off fine particles of lint. One of these men who was chasing hot boxes, opened a box and he found the sides of the box entirely lined with lint that was thrown off from the waste, and when the box was jacked up and the brass removed, it was found that this lint had worked between the journal and the journal bearing and had embedded itself in the babbitt. If any of you are bothered with an epidemic of hot boxes, in addition to the things mentioned in the paper there is one thing I would advise you to look after, and that is the waste.

Mr. O'Connor: We have found the best character of waste to use is a mixture of 40 per cent wool and 60 per cent cotton, to get away from that lint. It is produced by the collar of the journal and more so by packing the boxes by the M. C. B. method.

There is a difference of opinion as to the value of the plug in the front of the box. Packing is best done by feeding the waste in, so that it will be in one piece, applied underneath the journal, which prevents the rising of the packing. We had the same condition that Mr. Zachritz mentioned in 1916.

Mr. Zachritz: The packing in this case was wool in long strands.

T. J. O'Donnell (Buffalo, N. Y.): There is one point I would like to ask the chief interchange inspectors if they agree on. If a train of meat comes into a yard, after it has run 540 miles, is it good railroading to lift every lid and test the metal to see if you should condemn the car to the repair track, to avoid the possibility of a "call down" from our operating officers if some of those journals give trouble on the next division?

The superintendents, of course, are very zealous to keep their hot boxes down to the lowest point, but we have had a lot of trouble with cars being set out and I contend it is not the best method to look for trouble unless it has approached you.

Now, you know what it means to tell your inspectors to try those journals and overcome complaints of heating. Instead of leaving the box alone, they will hook every box, and possibly you will have five or six cars of high class freight set out where the repair foreman will lift the brass, test it and let it go. But you have laid the foundation for a claim when you delay a car of meat from one fast train to another, usually from 8 to 24 hours.

I am supposed to approve of the expense for cut journals; and the incidental wheel work has gone up almost 150 per cent in the last two years. The reason is this: When you charge the delivering line for a cut journal and you have a lot of work, invariably you have no second hand wheels. The car owner gets the benefit of a new pair of wheels at the expense of the delivering line. The result is, instead of a $5 or $10 charge, you have probably a $21 charge. You are doing a lot of harm, directly, in good weather when the train and the boxes are running well and your trucks are square, in trying to discover defects that really would take care of themselves if you keep the hook away from the journal.

J. J. Gainey (Southern): I agree with Mr. O'Donnell that there is no use of looking for trouble. During the strike I think we had in the neighborhood of nine hot boxes in 83 days. Some of those journals had cuts in them, and they were on our fast passenger trains. Brasses were applied to them and they were properly packed, and those wheels have been running 60 days and not giving any trouble.

I believe if in all terminals, on starting out trains, they are properly taken care of with the paddle, as instructed by the Galena Signal Oil Company you can prevent 90 per cent of your hot boxes.

Mr. Cheadle: We handle on our line a great deal of fruit. It comes to us on a schedule of 30 miles an hour and we deliver it on a schedule that averages 40 miles an hour. I decided to stop using the packing hook. I took one side of the train, and I told the man on that side to stir up the packing in every box, according to the Galena recommendations. On the other side, I did not lift a lid. Ninety-nine per cent of the hot boxes were on the side where we stirred the packing up.

Mr. Gainey: You did not have an experienced man to handle it as it should have been handled.

E. H. Mattingley (B. & O. C. T.): I was very much pleased with the items which Mr. O'Connor enumerated as to the causes of hot boxes and the special treatment that should be given the various parts of the box and its contained parts in the application of wheels. We do not give the wedge the attention it deserves, we look at the journal bearing and if it is at all defective we will renew it; but we will put the wedge back in a defective condition on a new bearing and expect it to function properly.

While there is a great deal of contradiction regarding the subject, I believe that the tight journal box used today is absolutely wrong. Oil has a flash point, and when your heat reaches that flash point you have a blaze.

Now, if you start a car out of the terminal, properly packed, new journal bearing, new journal, new journal box, new pedestal, possibly a passenger car, you are going to have a certain amount of friction until the bearing becomes

properly fitted to the journal. With that friction, you naturally have heat. Where you have excessive heat above the normal running temperature, you are bound to consume oil, which will go off in a blue gas that will not lubricate. Now, unless you have something to compel that temperature, to stay below the flash point, you are going to have a hot box. The air cooling process is the best known today. I feel we are closing our boxes up too tightly to properly take care of the gas in them, which will ignite at the flash point.

Has anyone had any trouble with hot boxes, with the journal box lids missing?

W. G. Wallace (American Steel Foundries): An engineer running a very fast train on the New York Central Lines, recently came up to me with a proposition of an air-cooled box, just exactly what Mr. Mattingley has spoken of. He stated that where he had trailers that were beginning to get hot, if he raised the cover and put a chip between the cover and the box and let in the air the box gave him no further trouble. He also stated that there was a certain amount of soapy material formed in the box.

Mr. O'Connor: In 1917, we made an exhaustive test with a baggage car, having 5½-in. by 10-in. journals and a light weight of 57 tons. We loaded 22 tons of axles directly over the body bolster. We had that car in a train that was scheduled to make a mile a minute between stations. We had a pyrometer to give us the temperature of each journal bearing under the car. We found that the normal temperature of a journal bearing is from 130 deg. F. to 160 deg. F. They will run successfully at 190 deg. F. We found that with the box lids closed we would run 40 deg. less temperature than with the box lid open. Now, because this high temperature is exposed to a low atmospheric temperature in the winter, the moment the train stops you do not find gas, where on the other hand, in a box where the lid is closed, this vapor puffs out. But that is a normal running condition. The great trouble is that many car inspectors do not know what the normal running temperature is. There isn't anything in the matter of the absence of journal box lids. You do not see the temperature, but it is there.

Mr. Mattingley: In your experience, how many journal boxes have you noticed blazing where the lid was missing?

Mr. O'Connor: I never saw very many.

Mr. Overton (Southern): Mr. Chairman, about 1900 or 1901, I was general car foreman at a point where one division was in a sand country and the other in a clay country, and this hot box question was disturbing us a great deal. I found the trucks were out of line, and we lined up the pedestals of all these cars. The next thing, we tested the running of the dope, to see how long the specifications as outlined by the Galena Oil Company would run in a clay country and how long in a sand country. Now, the cars in the sand country would operate about 800 miles less on one packing of the box before we had to disturb the packing.

Oil will last just so long in the waste, and when the foreign matter begins to accumulate in that waste and oil, then you are going to have a hot box, and when you remove the mechanical defects and lubricate the box regularly at certain periods, that will stop hot boxes.

Secretary Elliott: One railroad in East St. Louis was at one time making a practice of hooking journals, and some of the roads were kicking about it, because they were being carded for it. We found they were taking out journals that were not giving any temperature. Finally, they were told that if they wanted to take them out they would have to pay for them. That was one of the large railroads. I thought it was a very poor practice, and I agree with Mr. O'Connor that it is poor practice.

Mr. Barnaby: We have trouble on account of stock cars being loaded with sand. On a dry day, that sand drifts out and gets in the boxes; four or five cars behind the stock cars we have hot boxes. That is a practice that ought to be discontinued.

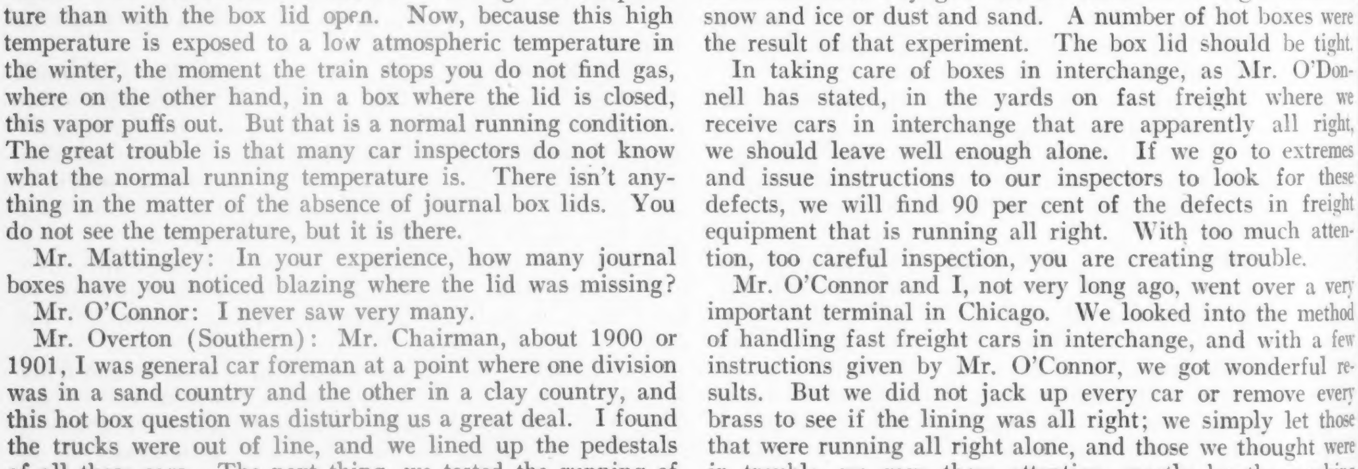
Secretary Elliott: They used to have a practice, at the East St. Louis National Stockyards, of bedding with sand, but they now use cinders.

James Reed (N. Y. C.): I have been very closely associated with Mr. O'Connor for a number of years, and I know that he has made a very careful study of this lubrication of hot boxes proposition, and he knows what he is talking about.

The idea of ventilating oil boxes is old; a number of years ago, it was tried out by a number of prominent railroads. I can remember on a certain railroad when the locomotive engineers would lift up the tender journal box lid and place a piece of wood or a stick or something to hold it up, with the result that they gathered all kinds of foreign matter—snow and ice or dust and sand. A number of hot boxes were the result of that experiment. The box lid should be tight.

In taking care of boxes in interchange, as Mr. O'Donnell has stated, in the yards on fast freight where we receive cars in interchange that are apparently all right, we should leave well enough alone. If we go to extremes and issue instructions to our inspectors to look for these defects, we will find 90 per cent of the defects in freight equipment that is running all right. With too much attention, too careful inspection, you are creating trouble.

Mr. O'Connor and I, not very long ago, went over a very important terminal in Chicago. We looked into the method of handling fast freight cars in interchange, and with a few instructions given by Mr. O'Connor, we got wonderful results. But we did not jack up every car or remove every brass to see if the lining was all right; we simply let those that were running all right alone, and those we thought were in trouble, we gave them attention, mostly by the packing iron, not by a whole lot of unnecessary oil. After the attention that we gave those boxes, we marked them to see whether they were going to their destination. We found that these cars, that the average inspector would mark for a defect, went to New York or Boston and returned with the same marks. So I believe we can overdo the inspection by following our instructions too closely.



A Sleeping Car on the New South Wales Government Railways

A Discussion of the Methods Used in Designing the C. M. & St. P. Gondola

By Wendel J. Meyer

THE method used in designing the C.M. & St.P. gondola cars as described in the November issue of the *Railway Mechanical Engineer,* is surely a step in the right direction away from "rule of thumb" methods of car design. Believing that the value of this interesting treatise may be enhanced by discussion, the writer submits the following comments on the analyses used by the author.

Center Sills

The center sill was assumed as a beam supported at the bolsters, carrying a load of 59,000 lb. uniformly distributed over its entire length and resisting an end load of 250,000 lb. applied at each end along the center line of the draft gear. Too much importance should not be attached to such assumptions and their resulting stresses.

The draft gear tests conducted by the United States Railroad Administration showed "that the force developed between cars is due to the inertia of the cars and when the slack is not bunched, is the same whether the struck car be standing alone or whether it be at the head of a draft of cars" (see page 130, "Draft Gear Tests of the U. S. Railroad Administration"). Therefore, the assumption that the center sills are loaded at each end simultaneously, is incorrect: the force probably is dissipated as it is transmitted through the sills, each cross member taking part in transferring the impact load to the superstructure and lading. The buffing stresses are maximum at the point of impact of the struck end and may be any value down to zero at the opposite end.

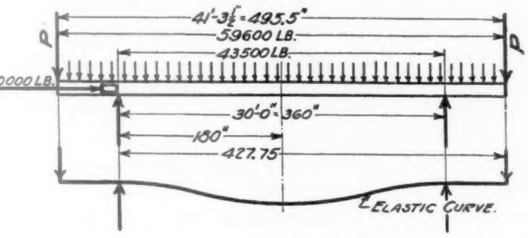


Fig. 1

The following method of approaching the actual stresses in a center sill of the type under discussion might be better, although the amount of load carried by the sills and the intensity of the buffing load are elements open for further discussion.

Fig. 1 shows the center sills supported at the bolsters, loaded with 59,600 lb. uniformly distributed. The end load of 250,000 lb. is assumed to be applied along the center line of the draft gear to the sills at the bolster of the struck end and is dissipated by the cross members, to zero at the opposite end. These are the same loads which were used by the author. Due to the rigidity of the end and side constructions, an indeterminate force (P), may be assumed to act downward at each end, making the sills a beam, virtually fixed at the bolsters and having an elastic curve as shown. The load between the bolsters is then:

$$W = (59{,}600 \times 360) \div 495.5 = 43{,}500 \text{ lb.}$$

The bending moment on the sills at the bolster is:

$$M_{bol.} = \frac{W\,L}{12} = \frac{43{,}500 \times 360}{12} = 1{,}305{,}000 \text{ in.-lb.}$$

and at the center of the car:

$$M_{cen.} = \frac{W\,L}{24} = \frac{43{,}500 \times 360}{24} = 652{,}000 \text{ in.-lb.}$$

The properties of the sills are as follows:

Area	29.4
Section Modulus (Top)	151.0
Section Modulus (Bot.)	144.0
Eccentricity	2.05
Stress Ratio (Top)	0.0204
Stress Ratio (Bot.)	0.0482

The unit stresses in the sills at the bolster of the struck end are:

Tension at top due to bending.	f = 1,305,000 ÷ 151 =	8,640 lb. per sq. in.
Compression at top (buffing).	f = 250,000 × 0.0204 =	5,100 lb. per sq. in.
Combined (tension)	f =	3,540 lb. per sq. in.
Compr. at bot. due to bending.	f = 1,305,000 ÷ 144 =	9,060 lb. per sq. in.
Compr. at bot. (buffing)	f = 250,000 × 0.0482 =	12,050 lb. per sq. in.
Combined (compression)	f =	21,110 lb. per sq. in.

At the center line of the car the buffing is assumed to have been dissipated in direct ratio to the length of sill traversed,

$$B_{cen.} = (250{,}000 \times 180) \div 427.75 = 105{,}200 \text{ lb.}$$

The unit stresses in the sill at the center of car are:

Compr. at top due to bending.	f = 652,000 ÷ 151 =	4,320 lb. per sq. in.
Compression at top (buffing).	f = 105,200 × 0.0204 =	2,150 lb. per sq. in.
Combined (compression)	f =	6,470 lb. per sq. in.
Tension at bot. to bending.	f = 652,000 ÷ 144 =	4,530 lb. per sq. in.
Compr. at bot. (buffing)	f = 105,200 × 0.0482 =	5,070 lb. per sq. in.
Combined (compression)	f =	540 lb. per sq. in.

The maximum unit stress obtained by this method is 21,110 lb. at the bolster and 6,470 lb. at the center, while the stress obtained by the author is 12,060 lb. at the bolster

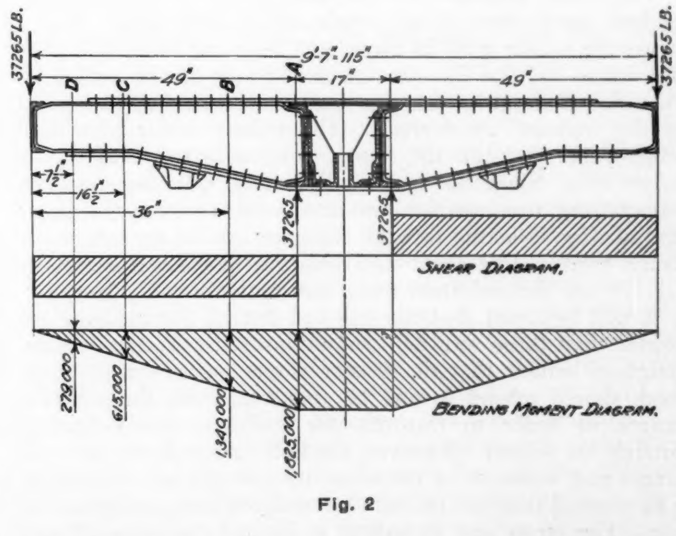


Fig. 2

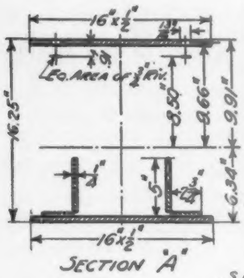
and 15,270 lb. at the center. In any repair yard, evidence can be found that the center sills are rarely damaged at the center but almost invariably at the bolsters. This logically indicates that the method given here is more nearly in accord with actual conditions even though it may not be absolutely correct.

Although, to conform to present practice, the buffing load is assumed to act along the center line of the draft gear, the writer wishes to question the correctness of such an assump-

tion. In his opinion, based on observation of the evidence that the coupler horn comes in contact with the striking plate, the buffing load should be considered as acting through the coupler horn instead of through the center line of draft gear.

Body Bolster

The author's method for analyzing the body bolster seems open to criticism. The reaction at the center is incorrectly taken as a single concentrated force and then after finding the bending moment at the center, it is incorrectly applied to a section through the center sill flange rivets. Since this bending moment results in a high stress in the cover plates, the center sill cover plate is incorrectly assumed to be brought into action by means of the rivets connecting it with the bolster plate. In order that such an assumption be true it



SIZE	AREA	ARM	MOM	ARM	AD²	I_o
14⅜"x½"	7.19	16.00	104.90	16.00	1839.0	—
2 Riv. @ .297	.59	14.84	8.76	14.84	130.0	—
2x4¾"x¼"	2.38	3.125	7.42	3.125	23.2	4.5
2x2¾"x¼"	1.38	.625	.86	.625	.5	—
16"x½"	8.00	.25	2.00	.25	.5	—
TOTALS	19.54	6.34	123.94		1993.2	4.5
STATICAL MOMENT						1993.5
14⅜"x½"	7.19	9.66	69.50			1998.0
2 Riv. @ .297	.59	8.50	5.01	$19.54 \times \overline{6.34}^2 =$		785.0
TOTALS		$M_s = 74.51$		$I =$		1213.0

$S.M._{(TOP)} = \frac{1213.0}{9.91} = 122.5 \text{ IN.}^3$; $S.M._{(BOT)} = \frac{1213.0}{6.34} = 191.6 \text{ IN.}^3$

$M = 1{,}825{,}000$ INCH LB.

TENSION AT TOP $= \frac{1{,}825{,}000}{122.5} = 14{,}900$ LB. PER SQ. IN.

COMPR. AT BOTT. $= \frac{1{,}825{,}000}{191.6} = 9{,}540$

UNIT LONGITUDINAL SHEAR $= f_s = \frac{VM_s}{tI} = \frac{37265 \times 74.51}{.50 \times 1213.} = 4{,}580$ LB. PER SQ. IN.

Fig. 3

would be necessary to have $(14.375 \times 0.25 \times 12{,}350) \div 4{,}690 = 9.45$, say 10 rivets on each side of the center line connecting the two plates. In analyzing the section taken at 12 in. from the center line of the car, the full section of the cover and web plates are taken without investigating whether this material is sufficiently connected to permit such an assumption.

The writer believes that the assumptions of the following method agree more closely with actual conditions. Fig. 2 shows the bolster with its forces and reactions indicated. The end forces—37,265 lb.—are assumed to act on the outside of the side sill because the truss load is delivered at this point by the transom brace rivets. The bolster center plate and center brace transmit the center reaction to the webs of the center sills. Since the center sill flanges will also assist in transmitting this reaction we may safely resolve the latter into two forces acting through the gage line of the center sill flange rivets. The shear and bending moment diagrams—Fig. 2—are derived from these assumptions.

It will be noted that the top and bottom cover plates are shorter than those shown in the author's illustrations. Some designers believe that the bolster covers on cars with wood floors should extend to and be connected with the side sill flanges in order to transmit the buffing stresses coming through the bolster. However, the holes through the side sill flanges and webs are in the same line and the net sill section is so reduced that this practice certainly offsets a questionable gain. The stress due to buffing is beyond the scope of this article and is not taken into account.

The bending moment at section A is 1,825,000 in.-lb. Assuming this to be resisted by the cover plates only, the stresses are:

$$\text{Top Plate.......} f_t = \frac{1{,}825{,}000}{15.75 \times 14.375 \times 0.50} = 16{,}110 \text{ lb. per sq. in.}$$

$$\text{Bottom Plate....} f_c = \frac{1{,}825{,}000}{15.75 \times 16 \times 0.50} = 14{,}500 \text{ lb. per sq. in.}$$

The proper riveting of the plates is obtained by using a rivet area equivalent to steel in direct stress. The equivalent area of a rivet is found by multiplying its area by the ratio between its ultimate strength and that of mild steel. Taking the values of 60,000, 42,000 and 95,000 lb. per sq. in. respectively as the ultimate strength of mild steel, rivets in shear and rivets in bearing, we find the equivalent area to be:

$$\text{¾-in. Rivet in single shear.} = \frac{0.4418 \times 42{,}000}{60{,}000} = 0.309 \text{ sq. in.}$$

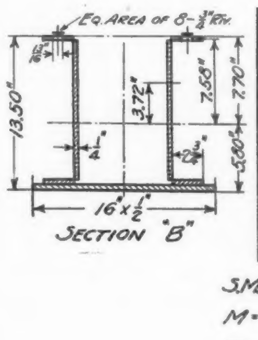
$$\text{¾-in. Rivet in bearing ....} = \frac{0.25 \times 0.75 \times 95{,}000}{60{,}000} = 0.297 \text{ sq. in.}$$

To develop the full strength of the top cover it must be connected to the bolster pans by $(0.50 \times 14.375) \div 0.297 = 24.2$, say 12 rivets in each flange, beyond section A. The bottom plate must have $(0.50 \times 16) \div 0.297 = 26.9$, say 14 rivets in each flange including the rivet at section A.

The number of rivets and their pitch will usually determine the required length of plates although an analysis of the webs at points not reinforced by the covers may require increasing this length.

Fig. 3 shows the detailed calculations for a closer analysis of section A. All material which logically may be considered, has been taken into account. This includes the net section of the top cover, the equivalent area of the rivets between center sill flange and bolster flange, the full area of the bottom cover and the compression portion of the bolster pan. The latter is arbitrarily assumed as about one-third of the depth but the error involved affects material near the neutral axis and so is of little consequence to the properties of the section. This analysis shows the stresses in the top and bottom covers to be respectively, 1,200 and 4,960 lb. per sq. in. less than those obtained by the approximate method and indicates that the size of the bottom cover could be reduced to save weight and cost.

Since the bolster is a short beam with a large concentrated load, it is always well to analyze for longitudinal shear in the webs. This is greatest at the neutral axis and is given by $f_s = \frac{V M_s}{t I}$ where f_s is the unit longitudinal shearing stress at the neutral axis, M_s is the statical moment of the area included between the neutral axis and the extreme fiber taken



16 Riv. @ .297	4.75	13.50	64.20	13.50	867.0	—
2x1 15/16"x¼"	.97	13.38	12.93	13.38	173.0	—
2x12½"x¼"	6.25	7.00	43.75	7.00	306.3	81.4
2x2¾"x¼"	1.38	.625	.86	.625	.5	—
16"x½"	8.00	.25	2.00	.25	.5	—
TOTALS	21.35	5.80	123.74		1347.3	81.4
STATICAL MOMENT						1347.3
16 Riv. @ .297	4.75	7.70	36.55			1428.7
2x1 15/16"x¼"	.97	7.58	7.35	$21.35 \times \overline{5.80}^2 =$		718.0
2x7.45"x¼"	3.72	3.72	13.82	$I =$		710.7
TOTALS		$M_s = 57.72$				

$S.M._{(TOP)} = \frac{710.7}{7.70} = 92.3 \text{ IN.}^3$; $S.M._{(BOT)} = \frac{710.7}{5.80} = 122.5 \text{ IN.}^3$

$M = 1{,}340{,}000$ INCH LB.

TENSION AT TOP $= \frac{1{,}340{,}000}{92.3} = 14{,}500$ LB. PER SQ. IN.

COMPR. AT BOTT. $= \frac{1{,}340{,}000}{122.5} = 10{,}920$

$f_s = \frac{37265 \times 57.72}{.50 \times 710.7} = 6{,}050$ LB. PER SQ. IN.

Fig. 4

about the neutral axis and I is the moment of inertia of the whole section. The calculation for statical moment and also for unit longitudinal shear is given for each section.

The tendency of web buckling is remote in a double web bolster unless the web is of unusual depth. The method for calculating the buckling stress in beams is given in the "Pocket Companion" of the Carnegie Steel Company and is easily applicable to bolster design.

Fig. 4 shows the detailed calculation for section B. The

full section of the top cover cannot be considered because it is connected to the webs by 16 rivets beyond the section at *B*, whose equivalent area is less than the plate area. The full area of the pans is taken into account for this is permissible as will be shown. The total tension in each web is transmitted to the center of the car by five rivets in bearing and one rivet in single shear. The amount of their equivalent area about the neutral axis of the section is

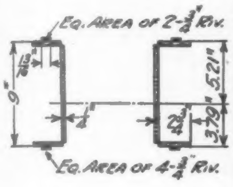
$$7.70 \times (5 \times 0.297 + 0.309) = 13.81$$

The amount of the tension portion of each pan is:

$$1.9375 \times 0.25 \times 7.58 + 7.45 \times 0.25 \times 3.72 = 10.62$$

Therefore the rivets are sufficient to develop the full strength of the pan.

It will be noted that the corners of the pans have been omitted. This is done because, due to flanging, this material is of doubtful value.



4 RIV. @ .297	1.19	9.00	10.69	9.00	96.2	—
2 x 1 15/16" x ¼"	.97	8.875	8.60	8.875	76.4	—
2 x 8½" x ¼"	4.25	4.50	19.11	4.50	86.1	25.6
2 x 2¾" x ¼"	1.38	.125	.17	.125	—	—
8 RIV. @ .297	2.38	0	0	0	0	—
TOTALS	10.17	3.79	38.57		258.7	25.6
STATICAL MOMENT.						258.7
4 RIV. @ .297	1.19	5.21	6.20			284.3
2 x 1 15/16" x ¼"	.97	5.09	4.93		10.17 x $\overline{3.79}^2$ =	146.0
2 x 4.96" x ¼"	2.48	2.48	6.16			I = 138.3
TOTALS		M_s =	17.29			

$$S.M.(\text{TOP}) = \frac{138.3}{5.21} = 26.6 \text{ IN.}^3;\quad S.M.(\text{BOTT.}) = \frac{138.3}{3.79} = 36.5 \text{ IN.}^3$$

$$M = 615{,}000 \text{ INCH LB.}$$

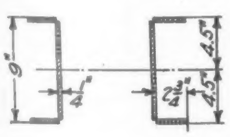
$$\text{TENSION AT TOP} = \frac{615\,000}{26.6} = 23{,}100 \text{ LB. PER SQ. IN.}$$

$$\text{COMPR. AT BOTT.} = \frac{615\,000}{36.5} = 16{,}850$$

$$f_s = \frac{37265 \times 17.29}{.50 \times 138.3} = 9{,}310 \text{ LB. PER SQ. IN.}$$

Fig. 5

In checking over the computations for section *B*, the writer finds that he had used the full area of the bottom plate instead of the equivalent area of 20 rivets. This, however, will have slight effect on the calculated stress because adding or deducting material on the heavy side of an unbalanced section does not change its section modulus very much.



$$I \text{ OF WEBS} = 2 \times \tfrac{1}{12} \times \tfrac{1}{4} \times \overline{8.5}^3 = 25.6$$

$$I \text{ OF FLGS.} = 4 \times 2.75 \times .25 \times \overline{4.375}^2 = 52.6$$

$$I = 78.2$$

$$S.M. = \frac{78.2}{4.5} = 17.38 \text{ IN.}^3$$

$$M = 279{,}000 \text{ INCH LB.}$$

TENSION AT TOP = COMPR. AT BOTT.

$$f = \frac{279{,}000}{17.38} = 16{,}050 \text{ LB. PER SQ. IN.}$$

$$M_s \text{ OF WEBS} = 2 \times 4.25 \times .25 \times 2.125 = 4.51$$

$$M_s \text{ OF FLGS.} = 2 \times 2.75 \times .25 \times 4.375 = 6.01$$

$$M_s = 10.52$$

$$f_s = \frac{37265 \times 10.52}{.5 \times 78.2} = 10{,}200 \text{ LB. PER SQ. IN.}$$

Fig. 6

The stresses given in Fig. 5 show that the cover plates should have been made longer so that more rivets would be provided to reinforce section *C*. The importance of analyzing several sections of the bolster is here indicated.

Increasing the cover plates would decrease the bending moment to be resisted by the unreinforced pans as shown in Fig. 6 for section *D*. It is important to note, however, that this would not change the value of the unit longitudinal shear. This shear is just beyond the safe limit which is usually given at 10,000 lb. per sq. in. and brings up the question as to the advisability of using 5/16-in. pans instead of ¼-in. Besides, a 5/16-in. pan would increase the bearing value of the rivets.

Side Frame

The side frame analysis is along lines which have been in use for some time but it should be pointed out that the method is more or less an approximation of the true stresses. Riveted joints are rigid and bring in high secondary stresses. The members of the truss do not meet in points and this brings in additional eccentric stresses. Then there are weaving and bulging stresses. The bulging stresses are roughly approximated by the author, but assuming the wood lining to reinforce the top chord is open to question. The effect of buffing on the side frame has been entirely neglected.

Conclusion

The writer has gone into the bolster stresses in some detail in order to hint at the vastness of the analysis of car design. A proper study of all the stresses in the car structure in service would take time and earnest effort, but these would not be wasted. Here is indeed a field of research which has hardly been touched.

The so-called practical man is prone to smile at theoretical analyses but this tendency is disappearing. Theory and practice always agree when the theory is correct and the practice is properly interpreted. If theory and practice apparently do not agree, then either the theory is incorrect or else the observation of the effects has not taken in the true facts.

Recent Decisions of the Arbitration Committee

(The Arbitration Committee of the A.R.A. Mechanical Division is called upon to render decisions on a large number of questions and controversies which are submitted from time to time. As these matters are of interest not only to railroad officers but also to car inspectors and others, the Railway Mechanical Engineer will print abstracts of decisions as rendered.)

Insufficient Proof That Repairs Were Not Made

Peerless Transit Line tank car PTL-1422 was shopped at the Westwego, La., shops of the Texas & Pacific and on April 20, 1919, a repair card issued by that railroad covering the application of one new coupler knuckle. The owner took exception to the bill, claiming that the knuckle was not renewed. This claim was based on an inspection following the return of the car to the owner's siding, by which the owner claims to have identified the original knuckle by a private identification mark placed on it before the car was repaired. The owner claims that a representative of the Atchison, Topeka & Santa Fe witnessed the marking of the knuckles and was also present at the inspection following the return of the car after the repair bill was rendered. Joint evidence to this effect, however, was not presented.

The Arbitration Committee decided that the evidence submitted is not sufficient to disprove the positive statement of the Texas & Pacific that the repairs were actually made as claimed, and the bill is sustained.—*Case No. 1233, Texas & Pacific vs. Peerless Transit Line.*

Delivering Line's Responsibility for Wrong Repairs

Bessemer & Lake Erie car No. 40407 was delivered home by the New York, Chicago & St. Louis on February 3, 1921, with one Bettendorf cast steel truck and two pairs of cast wheels in place of the arch bar truck with wrought steel

wheels standard to the car. When the delivery was made, a defect card was issued against the delivering line to cover the wrong truck and two pairs of wrong wheels. The New York, Chicago & St. Louis contends that the defect card should be cancelled and is willing to furnish a card to cover the wrong wheels, which, under the rules are delivering line defects. The owner of the car contends that the responsibility of the New York, Chicago & St. Louis for the wrong truck is proved by the fact that no defect card is offered from a more remote connection, claiming that the acceptance by that line of responsibility for the wrong wheels justifies the conclusion that the road also applied the wrong truck, and is therefore responsible under Rule 4.

The Arbitration Committee decided that the New York, Chicago & St. Louis is responsible under Rule 70 for the wrong wheels, but that it cannot under Rule 4, be required to issue its defect card for the wrong truck if the latter was not applied by it.—*Case No. 1234, New York, Chicago & St. Louis vs. Bessemer & Lake Erie.*

Protection of Delivering Line After Defect Card Is Issued

On April 16, 1921, the Atchison, Topeka & Santa Fe delivered SZX tank car No. 77 to the Peoples Tank Line at Coffeyville, Kans. The car owner later requested the Peoples Tank Line to forward the car to the General American Tank Car Corporation at Sand Springs, Okla., for repairs. The car moved over the Missouri, Kansas & Texas, and on its receipt the General American Tank Car Corporation requested a defect card for delivering line defects. The Missouri, Kansas & Texas furnished a defect card on May 17, covering several defects to the jacket and tank head caused by the cornering of the car. This road in turn requested protection from the Atchison, Topeka & Santa Fe, under Interchange Rule 4, on the ground that the Santa Fe had acknowledged that the defects existed when the car was delivered to the Peoples Tank Line. This request was declined. The Santa Fe stated that it had received the car under load from the Missouri, Kansas & Texas on April 8, 1921, and that the movement in question followed the discharge of the load at Augusta, Kans. The Santa Fe claimed that the car was in no accident while on its line, that it was received from the Missouri, Kansas & Texas in the damaged condition, and had been under load since the damage was done.

The Arbitration Committee decided that the Missouri, Kansas & Texas, having issued its defect card, is responsible for the defects in question.—*Case No. 1235, Missouri, Kansas & Texas vs. Atchison, Topeka & Santa Fe.*

An Application of Rule 32

Coal car No. 5289 of the Fort Smith & Western was broken in two while moving in a train on the Pittsburgh & West Virginia on November 7, 1920, the failure resulting from a burst air hose. The car was of wooden construction, equipped with metal draft arms and of 80,000 lb. capacity. The handling line claimed that the car was not derailed but that it had to be loaded on another car, over which one end of the car body had telescoped, to be taken to the shop because it could not be handled in the train on its own wheels. The Pittsburgh & West Virginia first asked disposition of the car under Rule 112, delivering line responsibility, but later changed its request to come under Rule 120, owner's responsibility, claiming that all longitudinal sills had previously been spliced and were badly deteriorated. The handling line claimed that the car was not derailed at the time it was damaged but that in moving the car out of the train to a side track it was in such condition that it would not take the curve and one pair of wheels dropped off the rails.

The committee decided that the damage to the car was due to unfair usage under Rule 32, for which the handling line is responsible, and that Case No. 1186 applied.—*Case No. 1236, Pittsburgh & West Virginia vs. Fort Smith & Western.*

Does Rule 113 Apply to Relations Between Railroads and Industries?

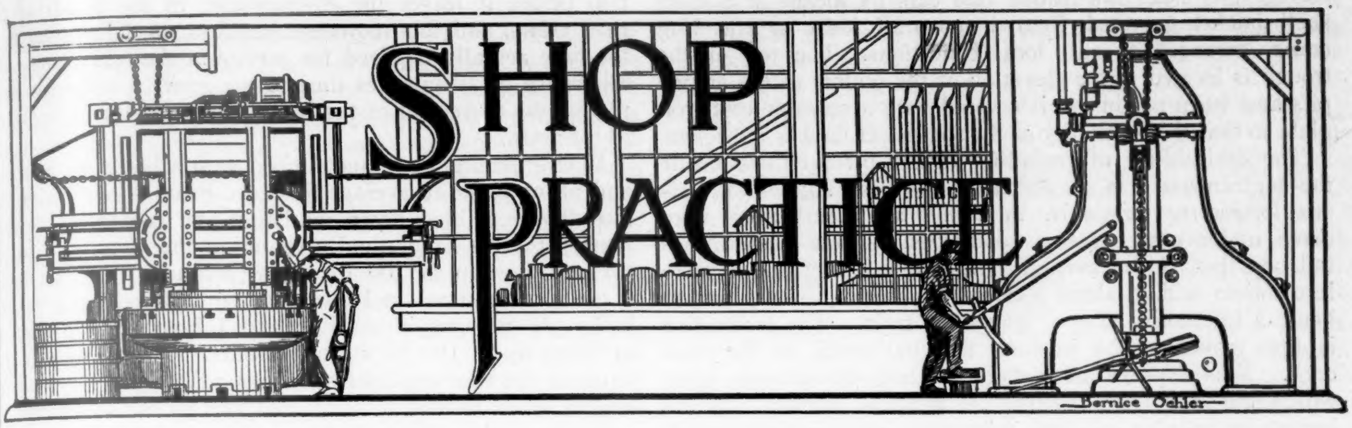
Fire, caused by lightning, which destroyed the warehouse of the Pierce Oil Corporation at Osceola, Ark., on July 6, 1921, spread to and badly damaged the oil corporation's tank car POCX No. 2230, which was unloading gasoline at the time. The spur on which the car was standing was built and is owned by the St. Louis-San Francisco, but is for the sole use of the oil company. The Pierce Oil Corporation claims that under the interchange rules the railroad company is responsible for the damage to the car, citing Rule 113 to substantiate its claim. The oil company does not own or control trackage outside of its property line and does not receive cars home for repairs except at Ft. Worth, Tex.; Texas City, Tex., and Sand Springs, Okla., and contends that the car was in the possession of the railroad company at the time of the fire, citing the fact that the railroad loaded the tank and salvage of the damaged car on two flat cars and shipped them to the oil corporation at Sand Springs, Okla., in violation of an interpretation of Rule 120 (1921 code) as evidence that the railroad recognized this as a fact. The railroad holds that Rule 113 was framed solely for convenience in effecting settlement between railways and not for establishing responsibility between a railway and the industries which it serves, and raises a question as to whether the rules of interchange apply to a case of this nature.

The Arbitration Committee rendered the following decision: "Rule 113 does not apply. It is understood that there was no side track agreement between the interested parties. According to the information furnished in agreed statement of facts, the car was evidently in the possession of the owner when the damage occurred. It is not evident that the St. Louis-San Francisco is responsible for damage to this car.—*Case No. 1238, Pierce Oil Corporation vs. St. Louis-San Francisco.*

Application of Rules 32 and 43 to Damage Caused in Switching

Cincinnati, Indianapolis & Western gondola No. 10032 was broken in two in switching over the hump in the Pennsylvania System yards at Scully, Pa., on October 11, 1920. On November 1, 1920, the Pennsylvania furnished the owner an inspection certificate showing an estimated cost of repairs of $329.40 for labor and $273.50 for material. The car, which was of wood construction, had received general repairs to the extent of $600 eight months previous to its failure, but they did not include reinforcement. The car was neither derailed, cornered nor side swiped. At the time of the accident it was the first of a five-car cut under the protection of one rider, and in addition to the damage which it received, the steel end sill on the first of the standing cars was broken. The owner contends that the damage was caused by collision or impact other than that occurring in regular switching, making the Pennsylvania responsible. The Pennsylvania contends that under the first interpretation of Rule 43, in the 1919 code, the responsibility is clearly the owner's and cites decisions Nos. 1157, 1165, 1166 and 1185 as being parallel.

The Arbitration Committee decision is as follows: "The evidence presented does not show that damage resulted from any of the conditions enumerated in Rule No. 32. The car owner is responsible."—*Case No. 1239, Cincinnati, Indianapolis & Western vs. Pennsylvania System.*

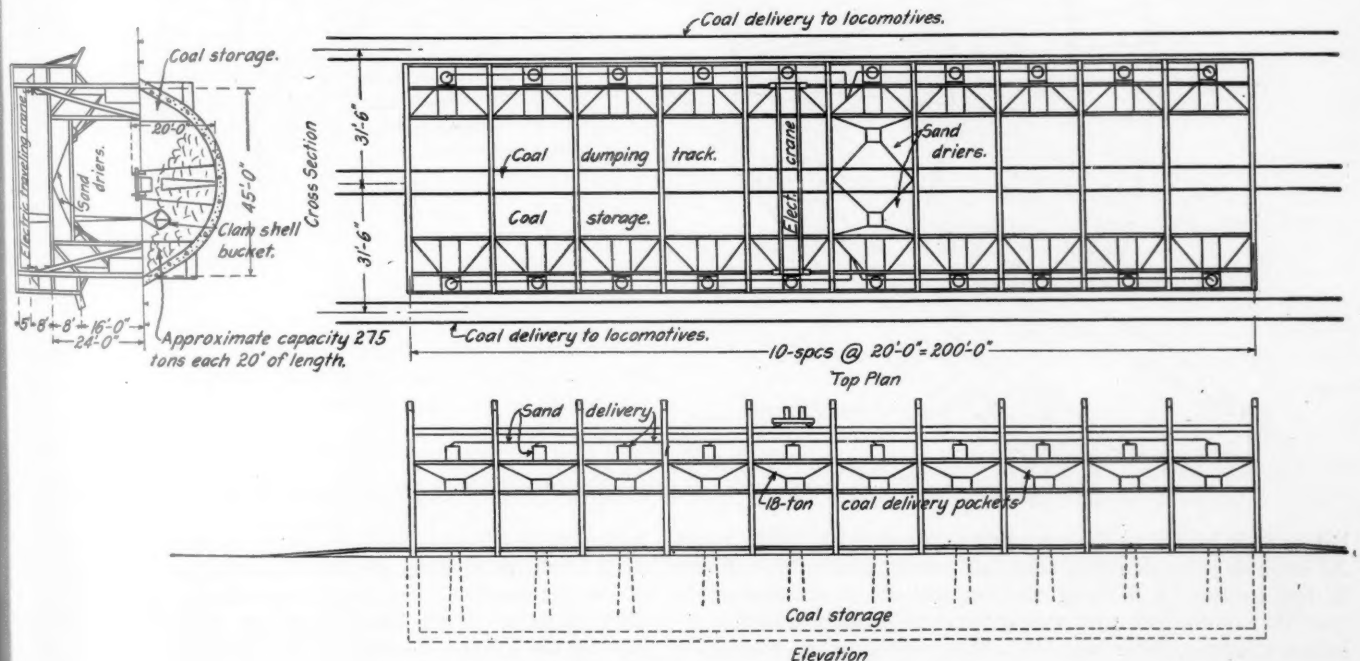


An Innovation in Locomotive Terminal Design

Rectangular or Circular Enginehouses with Inside Cinder Pits Designed for Promptly Turning Power

As the result of extended studies of locomotive terminal operation, designs for engine terminals have been developed by the National Boiler Washing Company, Chicago, the special features of which are the inclusion of the ash-pit facilities at each stall inside the enginehouse. With these designs, which include the adaptation of the inside cinder pit to enginehouses of the customary type as well as to houses of rectangular design, the plan of operation contemplates that the locomotive will be removed directly from the train to its track in the engine house by the road crew and that on outbound movements the road crew will take the locomotive from the house directly to the train. This method of operation, it is estimated, will effect a saving of several locomotive hours consumed in intermediate engine terminal movements by each locomotive, a reduction in the amount of coal consumed by locomotives in the terminal, the elimination of hostler service and some reduction in the labor cost of cleaning fires.

As a part of its studies of terminal design this company has also developed a coaling plant in which the principal fuel storage is contained in a pit below the track level, to which coal is dumped directly from the cars and from which it is elevated to the service hoppers by means of a traveling crane.



National Coaling and Sanding Station, Longitudinal Type

As will be seen from the drawings, the cinder pit in effect is a large trough, 14 ft. wide at the top, located below and extending transversely to the enginehouse tracks, in which a stream of water, delivered at the upper end of the trough, is kept constantly flowing down the slope of the trough toward the end of the house. Provisions are made for washing down the sides of the trough at each stall during the time that a fire is being cleaned. As ashes are dropped into the pit they are washed down to an outside storage pit adjoining the end of the enginehouse, where the cinders and water accumulate, the latter to overflow into a sump from which it is pumped back into the service pit. From the

storage pit, ashes are loaded into cars by means of a clam shell bucket operated from a monorail hoist or traveling crane, arranged to suit local conditions. The top of the trough is located at the elevation of the bottom of the engine pits and when not in use is covered with a movable cast iron plate so that the continuity of the engine pit floor is unbroken.

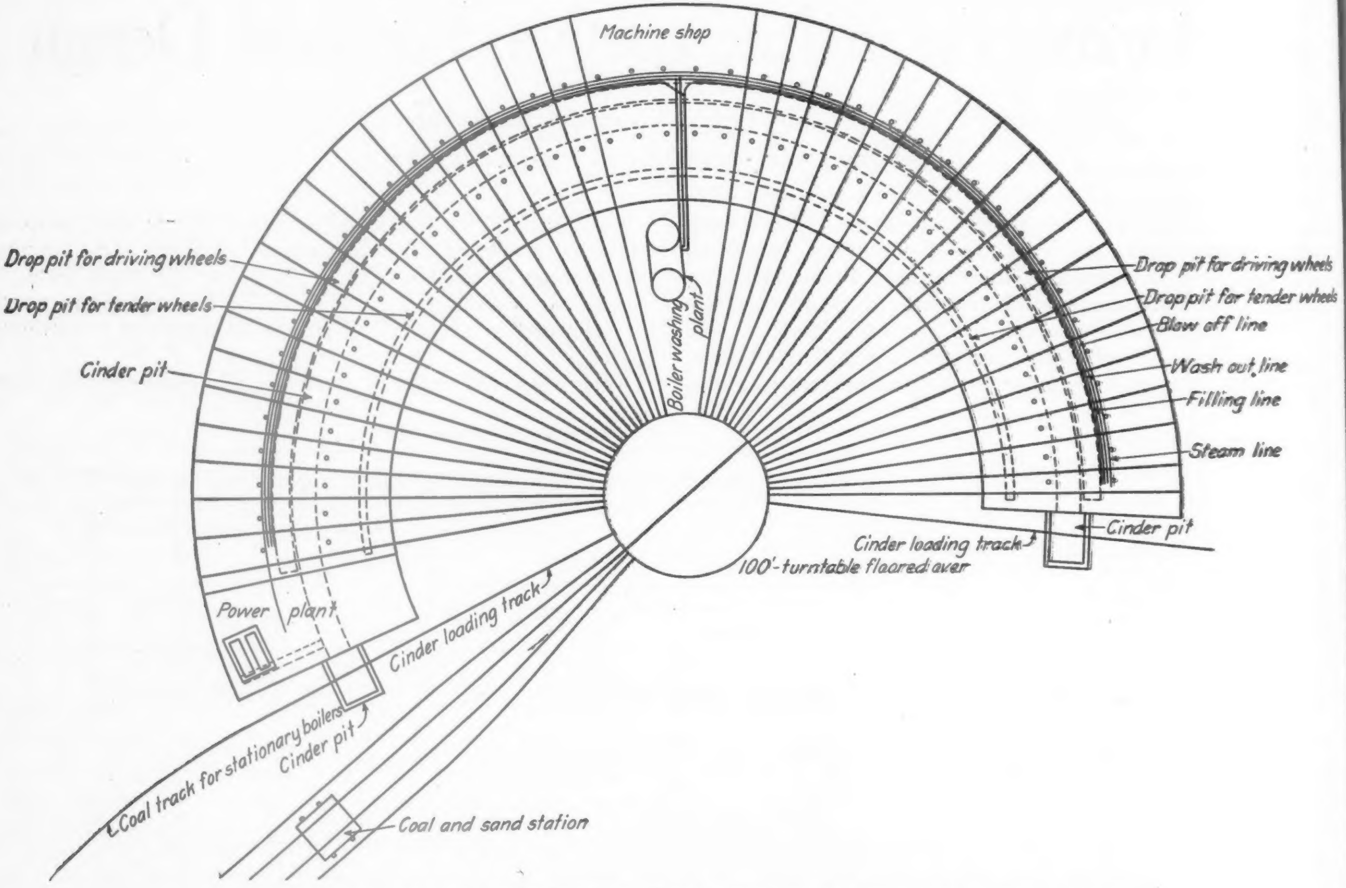
The desirability of including cinder pit facilities inside the enginehouse was suggested by operating studies of various locomotive terminals, in which all observations were made under good weather conditions. These observations indicate that at the average terminal handling 40 or more locomotives a day, about 3 hours 10 minutes is required to house a locomotive after it leaves the train. The locomotive is first moved to the inbound terminal track by the road crew. This requires an average of about 20 minutes, after which the locomotive spends 30 minutes waiting for the hostler or because of yard congestion and similar causes, before it is moved to the coal chute. At the coal chute about 20 minutes is required to take coal, water and sand. There is then an average delay of 45 minutes between the coal chute and the cinder pit and the locomotive spends another 45 minutes on the cinder pit. It is then moved to the wood pile to receive kindling for the new fire. This movement and loading the wood requires a total of 10 minutes. Moving the locomotive to and waiting for the turntable consumes 15 minutes and 5 minutes are spent in moving over the turntable and into the house.

With the National Consolidated locomotive terminal it is anticipated that the locomotive may be moved by the road crew directly from the train to the enginehouse without intermediate delays in the same time that is now required to deliver the locomotive on the inbound assigned track in terminals of conventional layout. On the outbound movement the locomotive stops at the coal chute for coal, sand and water. In all other respects, however, it is ready for its trip before it leaves the enginehouse, in the hands of the road crews, and this movement requires no delay other than the time actually required for service at the coal chute. An allowance of 30 minutes time to the crew is made for completing the movement of the locomotive from the enginehouse to the train.

Where terminals are unequipped with a hot water washing and filling plant an average time of 6 hours is required in the roundhouse to blow down the boiler and cool it by the customary process of gradually changing the water and to refill and fire up to 100 lb. steam pressure. Of this total, 4 hours is required in blowing down and cooling down the boiler, 30 minutes in refilling and 1 hour and 30 minutes in firing up to 100 lb. steam pressure. This ordinarily determines the time required in the roundhouse, as the running repairs generally can be completed well within this period.

In the design of the National Consolidated terminal the inclusion of a boiler washing plant is contemplated, together with facilities at each pit for cleaning the exterior surfaces of the locomotive, inspecting the machinery and making running repairs. This work is all to be performed without moving the locomotive after it has been spotted on the engine pit. The facilities include jib cranes serving each two pits, and suitable drop pits arranged either continuously under all engine pits or under two or more adjoining pits, as local conditions require.

With hot water washing and filling facilities and with the ash pit facilities located inside the house, the time required for knocking the fire, blowing down the boilers, filling it with hot water and firing up to 100 lb. steam pressure is estimated at 3 hours 45 minutes, during which time the locomotive will be cleaned and inspected, and ordinary running repairs made. Comparing the two sets of conditions, the total time in the hands of the mechanical department is reduced from 9 hours 50 minutes to 4 hours 35 minutes, thus



National Consolidated Locomotive Terminal Layout—Cinder Pit Inside of Round House

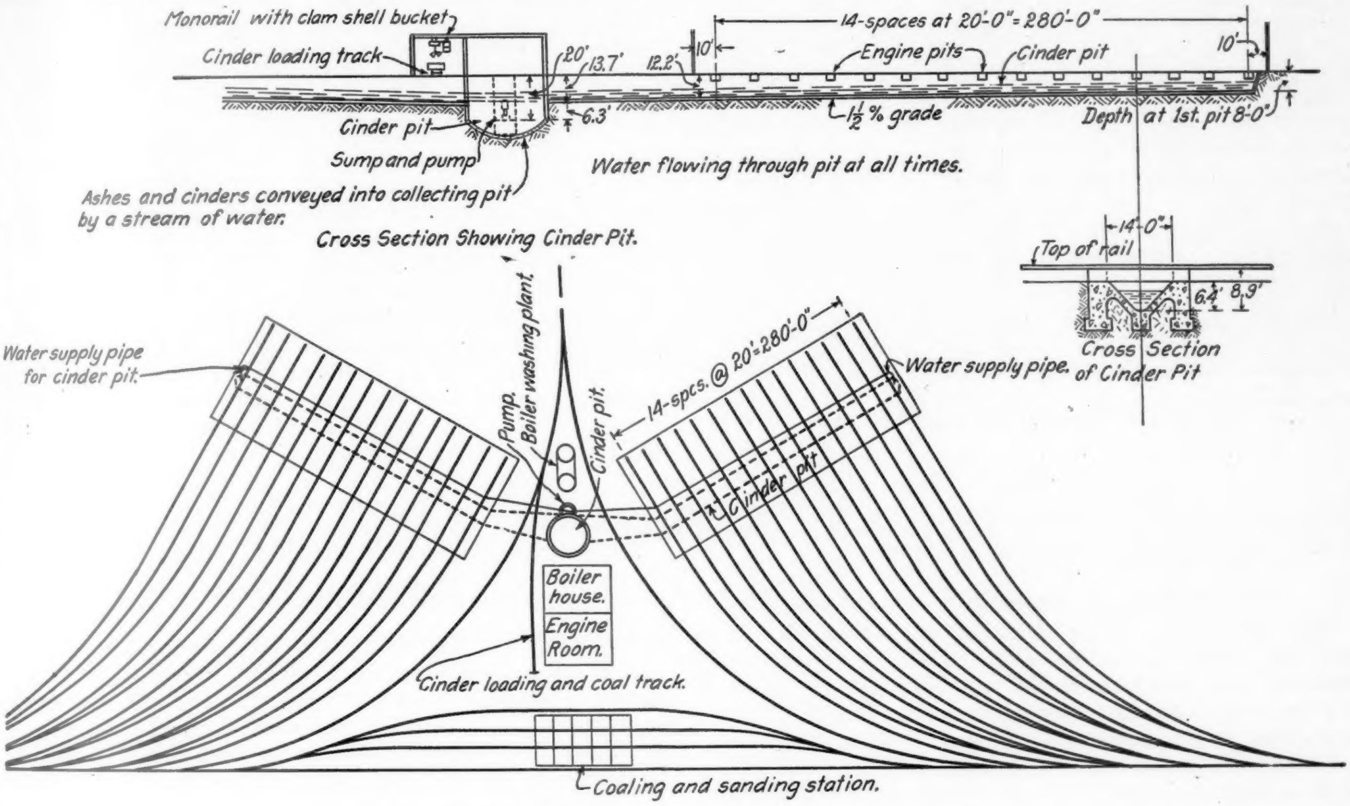
reducing the overall time from trip to trip by 5 hours 15 minutes.

In estimating the possible savings in the cost of turning locomotives through the National Consolidated locomotive terminal the field observations of actual operations at a number of existing engine terminals have been reduced to a basis of a terminal turning 42 locomotives a day, the equipment of which is typical of many comparatively modern engine terminals. The terminal includes no boiler washing plant and neither drop pits nor jib cranes are provided in the engine house. The coal chute is of concrete construction and the terminal is served by a wet type cinder pit and a motor tractor driven turntable. The turning of 42 locomotives per day includes blowing down and filling the boilers of 14 locomotives and washing out the boilers of seven additional locomotives. The labor cost of operating this terminal, on the basis of three 8-hour shifts, is as follows:

Hostlers:		
9 men, 8 hours each, at 72.9 cents per hour		$52.49
Coal Chute and Sand House:		
1 foreman, 8 hours, at 75 cents an hour	$6.00	
3 engineers, 8 hours each, at 57.25 cents an hour	13.75	
3 laborers (sand dryer and coal chute), 8 hours each, at 43 cents an hour	10.32	
Total		30.07
Cinder Pit:		
11 fire knockers, 8 hours each, at 43 cents an hour	$39.60	
1 crane operator, 8 hours, at 63.5 cents an hour	5.08	
Total		44.68
Wood Pile:		
3 men, 8 hours each, at 43 cents an hour		10.32
Turn Table Tractor:		
3 men, 8 hours each, at 45 cents an hour		10.80
Blowing Down and Refilling Boilers:		
6 men, 8 hours each, at 52 cents an hour		24.96
Boiler Washing:		
8 men, 8 hours each, at 52 cents an hour		33.28
Fire Builders:		
6 men, 8 hours each, at 52 cents an hour		24.96
Total daily cost, turning 42 locomotives		$231.56
Cost per locomotive turned		$5.51

Under the method of operation possible with a terminal of the type in which all conditioning of the locomotives, with the exception of taking coal, sand and water, is done in the engine house, the labor costs of turning 42 locomotives a day, under the same conditions as are set forth above, are estimated as follows:

Hostler service (one-half hour allowed each engine crew).		
Freight enginemen, 21 hours, at $1.16 an hour; freight firemen, 21 hours, at 88 cents an hour		$42.84
Coal Chute and Sand House:		
1 foreman, 8 hours, at 75 cents an hour	$6.00	
3 engineers, 8 hours each, at 57.25 cents an hour	13.75	
3 laborers (sand dryer and coal chute), 8 hours each at 43 cents an hour	10.32	
Total		30.07
Cinder Pit:		
8 men, 8 hours each, at 45 cents an hour	28.80	
1 crane operator, 8 hours, at 63.5 cents an hour	5.08	
Total		33.88
Wood Handling:		
3 men, 8 hours each, at 43 cents an hour		10.32
Blowing Down and Refilling Boilers:		
4 men, 8 hours each, at 52 cents an hour		16.64
Boiler Washing:		
6 men, 8 hours each, at 52 cents an hour		24.96
Fire Builders:		
Four men, 8 hours each, at 43 cents an hour		13.76
Total daily costs, turning 42 locomotives		$172.47
Cost per locomotive turned		$4.11



Proposed Arrangement of Rectangular Engine House with Inside Cinder Pit

The reduction in the number of fire cleaners included in the estimate of the number of fire cleaners required in the National Consolidated locomotive terminal is based on the ability to smooth out the peaks which occur at outside cinder pits because of their limited service capacity. With inside cinder pits a delay in cleaning the fire after a locomotive has been housed does not interfere with the operation of the terminal.

In addition to the reduced labor costs which is claimed for the new terminal layout, a saving in the cost of fuel and water consumed in the terminal of over 53 per cent is estimated to be possible. This includes the saving effected by the use of hot water for washing and filling boilers as well as that attributable to the elimination of delays in the movement of locomotives through the terminal. Based on the turning of 42 locomotives, washing seven and blowing down

and filling 14 boilers, all of which are fired up cold, the cost of coal in the average terminals of conventional design is shown in the table which follows:

COAL

	Tons of coal per day	Cost at $3.50 per ton
42 locomotives, 500 lb. coal each account delays between train and train	10.5	$36.75
21 locomotives fired up, hot water and steam in boiler, 1,256 lb. each	13	45.50
21 locomotives fired up cold. Firing up, 2,574 lb. each. Coal for blower steam 1,754 lb. each. Total	45.4	158.90
Total cost fuel per day		$241.15

WATER

	Gal. of water per day	Cost at $0.10 per M. gal.
7 boilers washed, 2,500 gal. each	17,500	1.75
21 boilers refilled, 5,000 gal. each	105,000	10.50
Total cost of water per day		$12.25
Total cost of fuel and water per day		$253.40

With the elimination of delays in the new terminal layout the fuel required to keep up steam pressure while handling the locomotives into and out of the terminal is saved. The water blown down from the boilers is used for washing boilers and the steam blown off forms part of the hot refilling water. Under these conditions the coal and water costs are estimated as follows:

COAL

	Tons of coal per day	Cost at $3.50 per ton
21 locomotives, hot water and steam in boiler, 1,256 lb. each	13	$45.50
21 locomotives fired up, refilled. Firing up, 1,256 lb. each. Coal for blower steam, 877 lb. each. Total	22.2	77.70
Total cost of fuel per day		$123.20

WATER

	Gal. of water per day	Cost at $0.10 per M. gal.
21 boilers refilled (condensate and fresh water) 2,500 gal. fresh water each	52,500	$5.25
Total cost of fuel and water per day		$128.45

This indicated a saving of $124.95 a day in the cost of fuel and water in favor of the National Consolidated terminal, most of which should be credited to the inclusion of a hot water boiler washing plant. However, $36.75 may be credited to the inclusion of the cinder pit inside.

The drawings show the application of the inside cinder pit in an engine terminal with the customary roundhouse and turntable layout and in a proposed rectangular enginehouse served by a wye in place of the turntable. The advantages of the latter arrangement are the saving in space inside the building permitted by the parallel arrangement of tracks, the ability to standardize the building design, so that it may be constructed in multiples of four-stall units and the lower cost of maintenance of the roundhouse leads and wye track as compared with the growing cost of maintaining turntables incident to their increasing length. The greater vulnerability of the turntable to accidents of a nature likely to completely tie up the terminal is also pointed out as favorable to the use of the wye. The arrangement of the terminal with rectangular houses shown in one of the illustrations is not intended to represent a standard form but is suggestive of what may be done with this type of layout.

Coaling Plant

In connection with this terminal design, a coaling plant has also been developed in which the main storage is carried in a concrete pit below the unloading track, which is approximately at ground elevation. A typical design of this type of coaling station is shown in one of the drawings. This is of the longitudinal type serving two engine tracks, with a single unloading track between them. This plant is a steel structure built in multiples of standard units each 20 ft. in length. For each 20-ft. bay, there is pit storage for 275 tons of coal and two service hoppers, one delivering to each engine track, having a capacity of 18 tons each. The steel structure is designed to carry a crane which travels longitudinally, with sufficient clearance between the top of the service hoppers and the bottom of the crane to permit the operation of a clam shell bucket for delivering coal.

The purpose of the development of this type of coaling station is to facilitate the rapid unloading of cars without the intermediate switching movements required at coal chutes of the elevator type, to provide a ready means for increasing the capacity of a coaling station without the necessity for the construction of a complete independent plant and the simplification of the design of the structure itself. A high degree of dependability is obtained by the use of an electric traveling crane and in case of emergency it is pointed out that the plant can be operated by a locomotive crane.

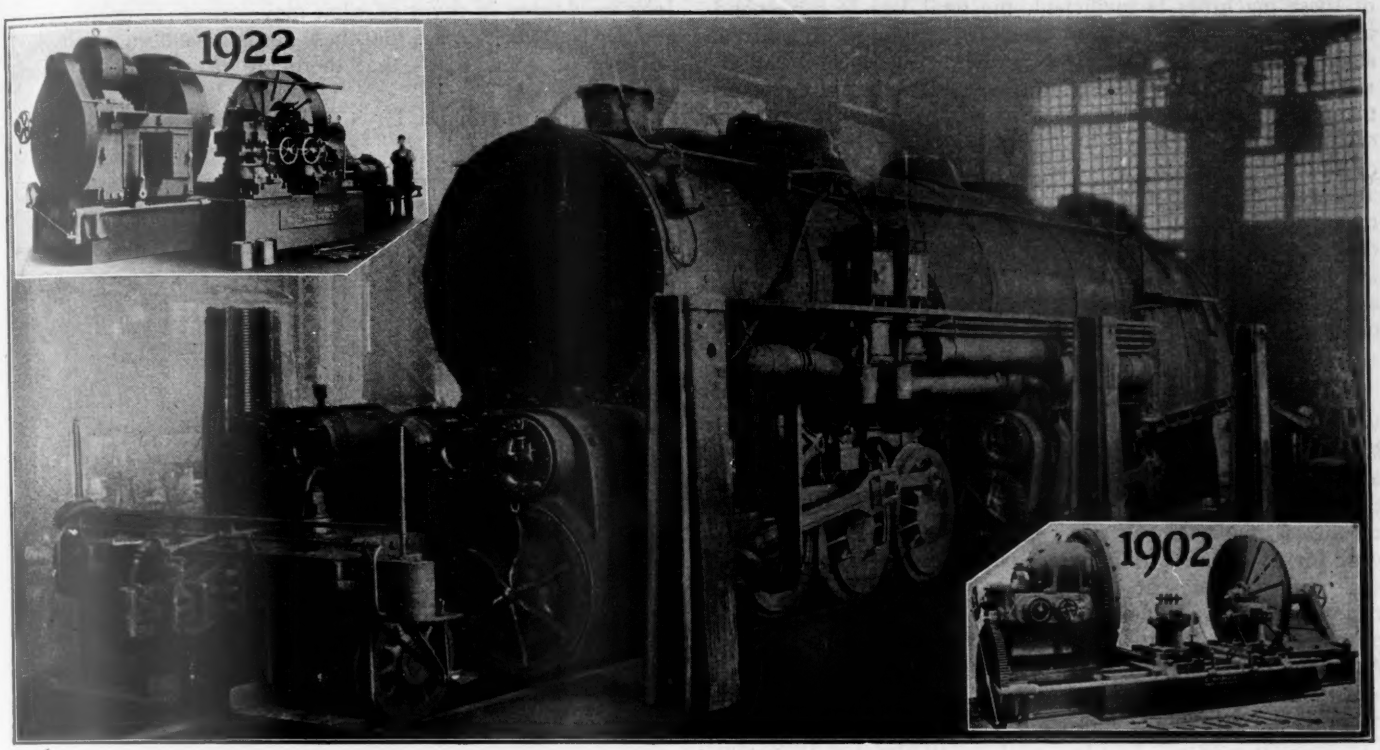
Where local conditions require a coaling station which will serve more than two tracks, a design has been worked out in which the crane, instead of traveling longitudinally over a single storage pit, travels transversely across two storage pits each 60 ft. in length and each serving two coaling tracks. Each coaling track has access to three service hoppers of 18 tons capacity each and the two pits, each 58 ft. wide and receiving coal from two unloading tracks placed 27 ft. from center to center, have a total storage capacity of 2,400 tons. Both types include sand drying facilities located at a sufficient elevation to permit the sand to fall into the dry sand storage by gravity, from which it is distributed by compressed air to the various service bins.

Patents have been obtained or applied for covering several arrangements of terminals, the application of the inside cinder pit to both rectangular and circular houses, and the coaling facilities just described.

How Do You Harden and Quench High-Speed Steel?

Do you thoroughly preheat it, or do you put it into the high heat chamber while the piece is cold? Experience has taught us that it is just as harmful to put a piece of cold high-speed steel into a high heat chamber without preheating as it is to quench it suddenly in cold water from a high heat. In the hardening of high-speed steel it has been found imperative that parts of any size be preheated to at least 1,600 deg. F. before being placed in the finishing heat of 2,250 deg. F., as the sudden shock of the intense temperature of the high-speed furnace frequently causes cracks which do not show until after the tool has been put into use. Experience again has taught us that the intricate part or parts, having large and small sections, should, to prevent breakage or cracking, be quenched in salts or molten lead heated to a temperature of 1,050 deg. F.; then cooled in oil or in the air; then drawn to the required temperature. All high-speed steel should be drawn after the hardening operation to temper and relieve strains. The proper equipment for treating high-speed steel consists of furnaces having a minimum of heat radiation and giving a constantly uniform temperature throughout. Furnaces which can be controlled accurately and held to steady temperatures are essential.—From a folder published by the Chicago Flexible Shaft Company.

THE EASTERN RAILWAY of France now has more than one-quarter of its locomotives fitted with audible cab signals. The total number of locomotives in service at the present time is, for passenger trains, 1,200; for freight trains, 798; total 2,018. Of these, 428 passenger engines and 144 freight engines are fitted with the signal apparatus. Ramps have been installed at 390 distant signals and at 130 home signals. The company plans to fit up 1,278 more locomotives before the end of 1923, and to install 1,560 additional ramps.



Can Modern Locomotives Be Repaired Economically With Machinery 20 Years Old?

Lack of Modern Machinery Handicaps Railroads

Net Earnings Are Reduced by Need of Machinery to Repair Equipment with Desired Speed and Economy

By E. L. Woodward

BROADLY speaking, the machine equipment of railroad shops and enginehouses affects net earnings in two ways, and is therefore of interest to the highest executive as well as mechanical department officers. In the first place locomotive and car repair costs are bound to be excessive without sufficient heavy modern machinery, in proportion to the increased amount and size of equipment, to reduce labor costs to a minimum. Second, lack of machine facilities delays repair operations, holding equipment out of service in shops and enginehouses longer than would otherwise be necessary and cutting down revenue-earning hours. Shop machinery also represents an investment which, in the present state of railroad net earnings and credit, should be subject to the closest scrutiny by mechanical, purchasing and higher executive officers.

PRESENT machine equipment in railroad shops and enginehouses averages 20 years old. This machinery is deficient in amount, size, power and convenience of operation. It appreciably increases maintenance of equipment costs which, in 1921, were one and one-quarter billion dollars, or 23 per cent of railroad gross earnings. This article attempts to point out how serious the machine deficiency has become, what influences have brought it about, and what can be done to remedy it.

The vital importance of shop machinery is indicated by the fact that in almost every railroad shop the output is limited by that of the machine department. Usually this department is lacking in both space and modern machinery. The erecting, boiler and blacksmith shops can in most cases handle more locomotive parts a month by increasing the force, but the machine shop is equipped with a certain definite number of machines which absolutely limits the number of rods, links, driving boxes, or wheels it can repair. True, machine shop output can be increased by putting on extra shifts, but past experience has shown this practice to be generally costly and unsatisfactory. Attention has been focused on the deficiency of machines more strongly than ever before, as a result of the strike and present attempts to secure greater shop output. Higher railroad officers are coming to realize that modern machinery is essential to efficient shop operation, and money spent for it is more than an operating expense. It is an investment which often pays better than equal investments in rolling stock.

Modern machinery fulfills the same important function for the railroad as for other industries, and immense numbers of machine tools are used in 403 locomotive shops, 568 car shops and 3,271 roundhouses on Class I roads in the United States. Obviously, if any considerable proportion

12,500,000,

of these machines is inefficient, the total loss is correspondingly great. Over 600,000 men are employed in railroad shops and roundhouses, and in 1921, the latest year for which figures are available, the cost of maintaining equipment was one and one-quarter billion dollars, or 23 per cent of all the money earned by the railroads. What proportion of this money could be saved by scrapping present obsolete and worn-out shop machinery and installing modern equipment would be hard to say. If only a fraction of one per cent was saved, however, the figures would still assume striking proportions. That important savings are possible is admitted by all unbiased observers familiar with actual shop conditions.

Present Machine Facilities Seriously Inadequate

Perhaps present railroad machine tool needs can best be visualized by noting the relatively small amounts of money spent in recent years for replacing existing shop machinery and to provide for increased needs. The facts of the situation will be evident from a study of Table I, showing in column A, the total operating expenses of the railroads each year for five years; column B, the money spent in repairing and replacing present machine equipment; column C, the ratio of B to A; and column D, investments in machinery purchased to make up deficiencies and fill increased needs. A longer period is not shown in this table for the reason that additions and betterments chargeable to capital account, column D, were not compiled by the Interstate Commerce Commission previous to 1917, and the figures for 1921 and 1922 are not yet available.

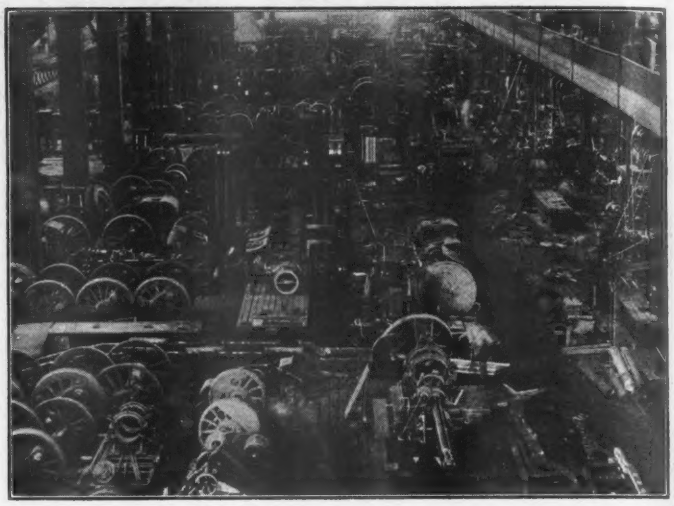
TABLE I.—STATISTICS FOR CLASS I CARRIERS

For fiscal year ending	(A) Total operating expenses	(B) Account 302 shop machinery	(C) Per cent of total expenses $=(B) \div (A)$	(D) Additions and betterments to shop machinery
Dec. 31, 1917...	2,829,325,123	14,552,997	.514	6,372,825
Dec. 31, 1918...	3,948,132,200	27,520,000	.696	7,775,692
Dec. 31, 1919...	4,378,285,227	24,802,814	.569	11,384,145
Dec. 31, 1920...	5,830,620,492	29,662,306	.509	7,466,414
Dec. 31, 1921...	4,562,668,302	19,249,027	.422	....

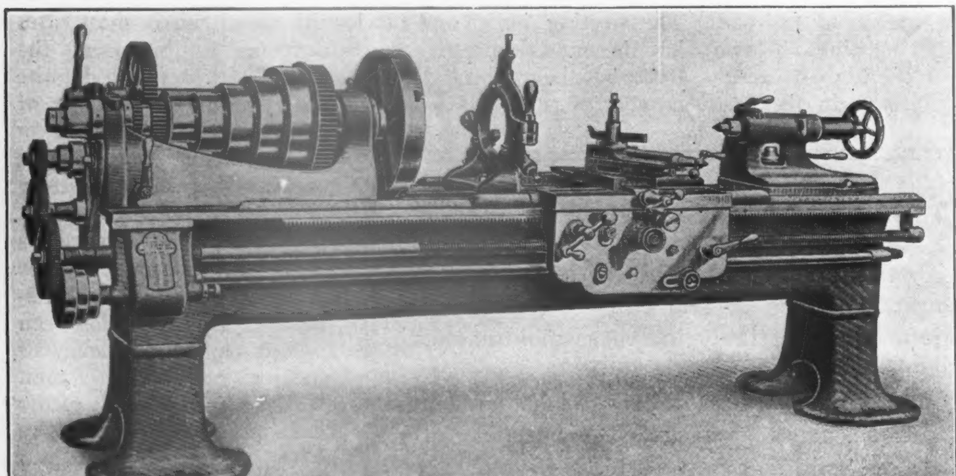
The money spent for shop machinery, column B, increased as operating expenses increased, reaching a maximum in 1920 of almost thirty million dollars. With the drastic reduction in expenses during 1921, it was natural to economize as far as possible on shop expense and Account 302 was reduced ten million dollars, or practically one-third. It was not only reduced but its proportion to the total operating expenses reached the record low point of .422, as shown in column C. This economy in shop machinery maintenance may have been, and probably was, necessary at the time, but it is merely a deferred expense which must be made up in the future. It is indicative of the general tendency to overlook machinery in favor of what may seem to be more pressing needs. Our point is that these needs have been overlooked so long on some roads that there are practically no needs more pressing.

Referring to column D, it will be noted that the money spent for additional machine facilities, chargeable to capital account, varied from over six million in 1917 to a maximum of eleven million dollars in 1919, then falling off. During 1921 and the early months of 1922, the retrenchments in operating expenses delayed betterment programs so that relatively few machines chargeable to additions and betterments were bought.

In connection with the eleven million dollars spent in 1919, it should be remembered that this unusually large amount does not properly represent a proportionate increase in machine tool facilities. Machine prices were then near their high peak and probably the number of machines actually secured did not greatly exceed those bought in 1917 for about one-half the price. It is certain that railroad investments in machinery in recent years have been insufficient to much more than maintain existing facilities, let alone make up past deficiencies, or provide normal expansion to care for the increasing number of heavier cars and locomotives.



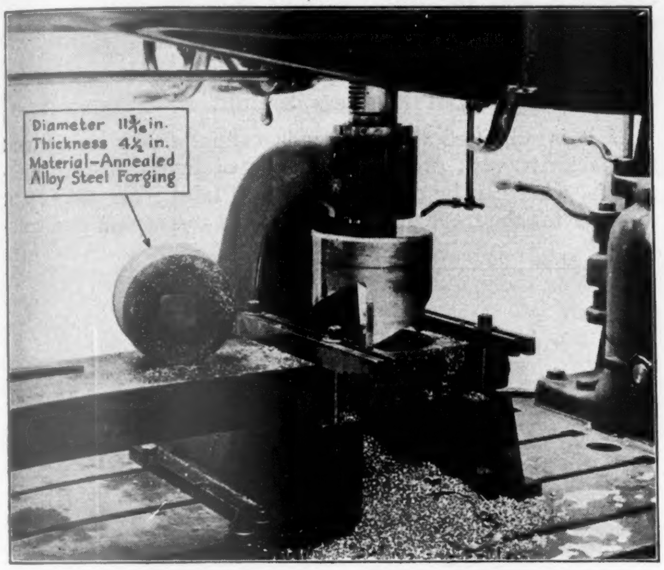
Congested Heavy Machinery Bay—The Average Railroad Machine Shop Is Lacking in Both Space and Modern Labor-Saving Machinery



While capable of many years more service, this machine is so inferior in productive capacity to the modern engine lathe that it can be used economically only in small shops and enginehouses having few turning operations daily. Other standard tools, like drills, planers and milling machines, 20 years old, are even more inefficient compared to modern tools.

Common Type of 20-In. Cone-Driven, Back-Geared Engine Lathe, Built About 1902

The poor condition on many railroads as regards shop machinery is also indicated by the number of machine tool programs which have been entirely cancelled or carried out only partially. Attention was recently directed in the columns of the *Railway Age* (page 826, November 4 issue) to a definite case where a railroad having four moderate-sized repair shops made an exhaustive study of its machine tool needs, and outlined a program calling for an expenditure of $275,000 a year for ten years. This program was



Side Rod Bushing Hole Roughed Out in 23 Minutes on a Modern Radial Drill. What Manufacturer 20 Years Ago Would Have Dreamed of Attempting Such a Job?

initiated over two years ago and, owing to financial limitations, three machines only have been purchased in the interim.

There are men who say by inference, if not in so many words, that railroad shops do not need the highest type of modern machine tools; that railroads always have got along with more or less inferior tools, and always can. There is just enough truth in these statements so that they cannot be branded as absolutely false. For the majority of machining operations, highly specialized productive tools are not needed. That does not mean, however, that so simple a tool as a lathe should not have ample power, rigidity and ease of operation. Modern lathes are sufficiently superior in these respects to many of the lathes now used in railroad shops to enable them to effect savings which will more than pay carrying charges on the additional investment.

Machines 20 Years Old Cannot Push High-Speed Tools to Capacity

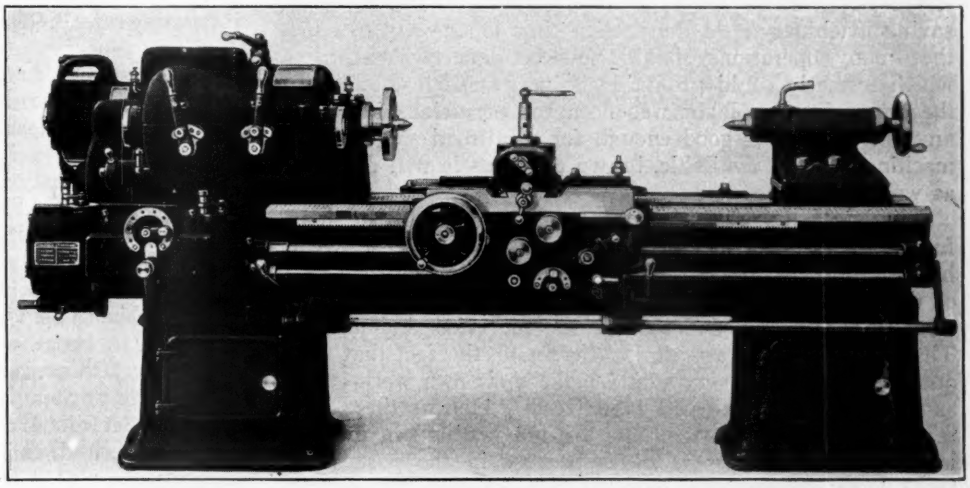
The condition of present machinery can also be appreciated from the fact that the average age of machine tools in the largest shop of an eastern railroad is 15 years. On two southern roads the machines average over 19 years old in each case. Unquestionably, even the simplest types of standard machines, such as lathes, planers, shapers, milling machines, drills, etc., have been improved so much in design during that period that railroads cannot afford to operate the older machines, except possibly at small isolated points where they will be used only two or three times a day.

Not only is the old machinery inadequate in amount, power and convenience of operation, but also in size, being totally unsuited to handle the heavy parts entering into modern locomotive and car construction. During the past ten years alone cars have increased 11 per cent in number; locomotives have increased 40 per cent in number and 50 per cent in tractive power. Have machine facilities been increased proportionately?

In many shops the tremendous possibilities of high-speed steel in cutting the cost of machine operations cannot be realized because the machinery lacks sufficient power to work these tools. In a recent specific case, a new high-speed tool was being tried out in a shop of one of the most prosperous roads in this country. Except for the wheel lathes, no machine was found in the shop capable of pushing this tool to anywhere near its capacity. The tool was adaptable to use on lathes, planers, shapers, or slotters, and was first tried on a small planer of ancient design, machining a driving box wedge. The lack of rigidity of the planer drive was such that the speed or feed could not be increased without violent chattering. The tool head had at least 3/32 in. lost motion back and forth on the cross feed screw, and was observed to spring back that amount after the completion of each cut. Sometimes considerable material has to be removed from the faces of shoes and wedges, and, with a planer of this type and present high machinist's wages, the cost of the operation is excessive.

The tool was next tested on a lathe which apparently was far older than the shop in which it was installed. This lathe was driven from a countershaft and pulley, on which the belt slipped every time an attempt was made to increase the feed or speed. The back gear shaft on this lathe was observed to have fully ⅛ in. play in its bearings and the result on power delivered at low speed can readily be

This modern lathe will work high speed steel tools to the limit, taking heavy cuts with accuracy and speed. Selective speed and feed changes are almost instantly obtainable. The main spindle can be started, stopped or reversed by either of two easily-reached levers. Wherever sufficient work is available this machine will show important savings over older types of lathes.



1922 Model, 20-In. Motor-Driven Engine Lathe—a Compact, Powerful, High-Production Tool

imagined. Unfortunately, such machines are not the exception but can be found in large or small numbers in almost every railroad shop in the country.

Reasons Underlying Present Machine Deficiency

As has been pointed out in these columns before, the small annual net earnings of the railroads in recent years has discouraged investors, so that capital needed to expand the railroad plant in proportion to the normal expansion of business could not be obtained. It has been difficult to get new equipment and even more difficult to secure the repair facilities needed to maintain new equipment. This explains why in many cases railroad shops and enginehouses are equipped as at present with so many machines which are antiquated, inefficient and costly to operate.

Another important reason is that mechanical department men have taken old machinery too much for granted, either entirely failing to show the managements how much money could be saved by the installation of modern equipment or else becoming discouraged after once pointing out the needs and getting no action. Many progressive mechanical department men on the other hand do realize the savings possible by new equipment, but their hands are completely tied by the financial inability of the railroads to provide the appropriations needed.

The comparative ease of getting money for new rolling stock as against new machinery has also operated to the disadvantage of the latter. In fact the difficulty in getting even small appropriations for machine tools has been so great that railroad men will patch, repair, weld in gear teeth, and frequently manufacture complete new tools in the shops, charging them to operating expense. Some shopmen take an almost unholy pride in their ability to devise ingenious makeshifts for some standard machine which could more profitably be bought. The expense of constructing these makeshifts in railroad shops is excessive and they are relatively unsatisfactory in operation.

Effect of Modern High Labor Costs

Another explanation of the generally poor condition of railroad shop machinery is that no longer than ten years ago, labor costs were fully 50 per cent less than now, and it was not relatively of as great importance to utilize labor-saving machinery. At the present time labor costs so much that many operations should now be done by machinery which formerly could profitably be performed by hand. In the days of cheap labor was born the pernicious idea that any old machine is good enough for a railroad shop, and if machines are not available, brawn and muscle will do about as well.

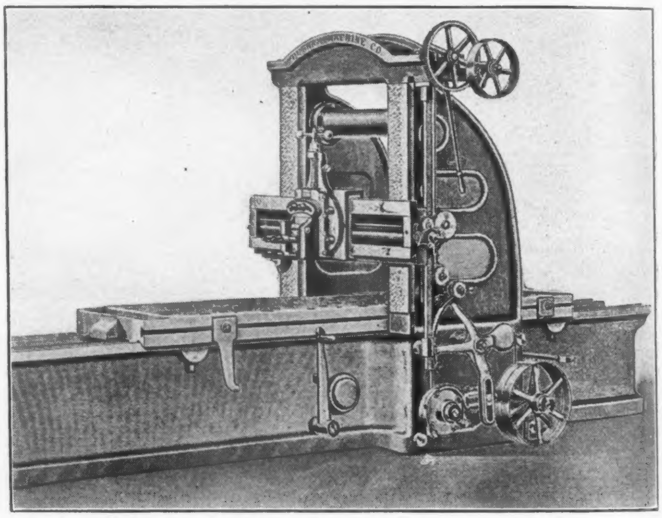
It is hardly necessary to defend the need of railroad shops for more and better machine tools, and such a defense would be absolutely unnecessary were it not that some railroad men of the old school have always got along with the old equipment and seem satisfied to continue the effort indefinitely. They forget, or at least are indifferent to, the fact that adequate modern machinery would make their own work easier as well as reduce railroad labor costs. One of these men recently said that managements are not justified in making large expenditures for facilities because in the past, peak loads have always been handled with existing equipment. True, each peak was handled after a fashion, but it is a question how successfully and how economically it was handled. In practically every case revenue was lost, perishables damaged while waiting shipment and, in the rush to get equipment through repair shops, costs were excessive.

There may be no justification for a plant and equipment able to handle with ease the peak load in any business. The plant should be available, however, to handle peak loads with a reasonable degree of efficiency and economy. That railroad equipment is not now in the latter happy condition is indicated by Secretary Hoover's recent statement that car shortage each year costs the general public (and the railroads) as much as the entire annual cost of administering the affairs of the federal government. One important reason for car shortages is lack of machinery and equipment for rapidly repairing cars, particularly steel cars.

It is not maintained that every railroad shop should be equipped with the latest types of modern productive machinery, but these machines should be installed wherever the volume of work warrants. Rugged standard types are needed elsewhere, and the best place for obsolete models, which waste valuable space and operator's time, is undoubtedly the scrap pile.

Machine Tool Budgets Should Be Prepared

If it is admitted that railroads cannot repair equipment satisfactorily with present machine tool facilities, the question is, what can be done about it? Plainly, one important thing is for the mechanical departments to prepare constructive machine tool programs, or budgets, based on accurate figures showing the cost of new machinery, the volume of work to be handled, and anticipated savings.



1902 Model Planer. Many Planers in Railroad Shops Are Older Than This Machine. They Lack the Power, Rigidity and Flexibility of Modern Planers and Are Costly to Operate on Production Work

In establishing a budget for a certain road it was estimated recently that twenty thousand dollars per thousand miles of track should be spent annually for shop machinery. It seems more logical, however, to base machinery purchases on locomotive equipment rather than mileage. This road is approximately 8,000 miles long, with 1,600 locomotives, and shop machinery having a present replacement value of $3,200,000. From a basis of normal deterioration and obsolescence, this machinery cannot be considered to have a useful life greater than 20 years and in order to maintain the plant, let alone care for increasing needs, 5 per cent should be retired and replaced annually. This means an expenditure of $160,000 per year, or $100 per locomotive per year. As a matter of fact, this road spent $400,000 in 1920 for machinery when prices were high. Had a scientific budget previously been in force, the railroad would have saved considerable money, inasmuch as it would not have been necessary to buy so much machinery at the prevailing high prices.

Improved Purchasing Methods Needed

There is opportunity for a great improvement in railroad methods of purchasing machine tools, and timely editorials

on this, and general machine tool subjects, have been printed during the past year in the *Railway Mechanical Engineer* as shown in the following table:

Machine Tool Editorials in the Railway Mechanical Engineer

An Old Fallacy	March,	1922
Buying vs. Making	April,	1922
Another Comment on Price Buying	May,	1922
Drill Grinders Needed	May,	1922
Why Grind Piston Rods	June,	1922
Why Continue to Use Obsolete Machinery	July,	1922
Grinding Car Journals	July,	1922
More Drop-Forging Work Needed	Aug.,	1922
Some Comments on Internal Grinding	Aug.,	1922
Meaning of the Term "Wood Butcher"	Sept.,	1922
Machine Tool Prices Advance	Oct.,	1922
Why Not Grind Air Compressor Cylinders	Nov.	1922
A Short-sighted Policy	Nov.	1922
Second-hand Machine Tools	Dec.,	1922
Engine Terminal Machine Equipment	Jan.,	1923

Railroad methods of purchasing machine tools have been criticized in three ways and with some justification. These include lump buying, the three-machine option and placing too much emphasis on price as opposed to quality. A railroad machine tool is an investment in which first cost is entirely secondary to the amount and kind of service rendered. With the present competition in the machine tool industry, price is a fairly accurate measure of serviceability and, since machine tools are used 15 or 20 years or more, productive capacity is far more important than first cost. The present practice of placing big shop equipment orders with one large manufacturer or dealer is objectionable because no one dealer represents all the best lines in the country and, in order to quote a lump sum lower than the total aggregate bid, he must include some machines not of the first quality. Considering machine tools as an investment, each one should receive separate consideration and be purchased in accordance with the individual needs.

Regarding the common practice of requiring the mechanical department to specify at least three makes of each type of machine tool desired, the objection to this practice is that any tool with outstanding features, or superior quality, is apt to have a somewhat higher price. Although the difference in performance may pay many times over for the comparatively slight difference of first cost, the purchasing department has no means of gaging the value of such differences and so places the order for the cheapest of the three tools pronounced acceptable. Unless mechanical departments have the privilege of specifying a particular make of tool, provided the difference of price is no more than a fair differential over the next best machine in the class, the railroads will rarely get the most efficient tools but will receive only the second or third best. Furthermore, they are apt to pay more than the inferior tools are really worth.

In large repair shops and enginehouses where productive capacity is of first importance, the high-duty machine is a paying investment at any price within reason. It is not maintained that in relatively small shops and terminals modern machines of the most improved type are needed. The solution of the problem is to leave the selection of machines in the hands of the mechanical department. Knowing the appropriations available and being responsible for maintenance of equipment costs, the mechanical department should not be debarred from specifying the best machine of a given type on the market if it feels that conditions warrant such action.

The arguments presented above hold also for the purchase of second-hand machines. The objections to second-hand machinery are that the first and best use has generally been obtained, and it is difficult to detect worn or defective parts. The railroads already have enough worn-out machinery in repair shops and enginehouses without installing machines which have already given their best service. Second-hand machinery should be purchased only with the greatest care, after a thorough detailed inspection.

It is vital that railroad executives and mechanical officers should appreciate more fully the present deficiency of shop machinery. Comprehensive machine tool programs, based on accurate cost figures and taking into account all overhead charges, should be prepared and presented to the managements in a concrete, readily understood form. With persistent effort along this line, the results in improved machine equipment of railroad shops will soon be evident, resulting in important reductions of maintenance-of-equipment costs.

Power Application of Valve Chamber Bushings

One of the erecting shop jobs which involves the expenditure of considerable time and physical effort is the application of new valve chamber bushings, unless some power-driven apparatus is available to perform this operation. The usual method is to employ a long screw through suitable circular plates to fit the bushings, and with nuts outside of these plates. Some form of ratchet wrench or device is then applied to the nuts and the bushings pulled into place by sheer brute strength. The operation takes considerable time and effort, especially when the bushings do not happen to be machined with the correct allowance for a force fit. It not infrequently happens that three or more men are required on the end of a long ratchet wrench to pull the bushings into place, four hours being needed to apply the bushings on both sides of a locomotive.

Valve Chamber Bushings are Rapidly Pulled into Place

The device illustrated performs this operation by means of a pneumatic motor, and in the shop where it is used, the men wonder how they managed to get along without it so many years. It takes about 15 minutes to set up the device and 10 minutes to dismount it. Bushings can be pulled into place on each side of a locomotive in from 15 to 20 min., the total time assuming the longer period, therefore being 90 min. This is a considerable saving over the four hours formerly required.

The power unit is the ordinary motor-driven flue cutter and gearing, used in cutting flues in the front ends of boilers. This gearing drives a right and left long screw of large proportions suitably connected to the bushings by means of circular plates and heavy hexagon nuts. A ball thrust bearing is provided which reduces the friction to a minimum. After this device has been set up, the most obstinate bushings are pulled rapidly into place, one advancing sometimes ahead of and sometimes behind the other, depending upon the relative friction. Both bushings eventually come solidly up against the shoulders and the job is done.

Specimens of Welding Work Done in the Southern Pacific General Shops at Sacramento

Welding Practice on the Southern Pacific*

How Electric Arc and Gas Welding is Used in the Sacramento General Locomotive and Car Repair Shops

ALTHOUGH much has been written concerning the application of electric arc and oxyacetylene welding we have yet much to look forward to, as during the last few years an unusually rapid advance has been made in both of these methods of welding and they have now become recognized as an art very essential to many industries—particularly the railway industry.

One instance is the making of car end sills for repairs to steel cars. These have deep flanges and are of irregular shape. It would be a difficult and expensive operation to flange these sills by hand. We therefore cut out a vee in the flanges with the cutting torch. The first or straight bend is made with the rolls; then the short bends are made, causing the flange to close up where it had been cut out. It is then welded either by the electric arc or oxyacetylene process, making a substantial and economical job. This is shown in Fig. 1.

Reclaiming Boiler Tubes and Flues

In the tube shop every day hundreds of various sizes and lengths of boiler tubes are repaired. Autogenous welding makes it possible to reclaim many tubes which otherwise, on account of the deep pitting, would have to be scrapped. These are reclaimed by filling in these pits by welding with either the oxyacetylene or electric arc; this operation restores them to serviceable condition, making them practically as good as new tubes. A number of superheater flues reclaimed in this way are shown in Fig. 2. Many of the larger size flues, from 4 in. to 5½ in. in diameter, that are beyond repair due to excessive pitting are split full length of tube with the oxyacetylene torch and flattened out. The plate thus obtained from the tube is used for various purposes. Practically all the larger tubes scrapped are reclaimed in this manner.

Oil drums come in for repairs and we often find them badly damaged, caused by coming in contact with heavy bodies resulting in deep dents in the drums. Some of these dents are so deep that it is impossible to straighten them with internal hydraulic pressure. It is therefore necessary to cut off one end of the drum with the oxyacetylene torch and straighten the drum by physical effort. After the drum is straightened, the end is fitted back to its original position and welded with either the oxyacetylene or electric process. This makes a strong durable job, and the cost is well within the limits of the original price of the drum. One partly, and one completely, repaired drum are shown in Fig. 3.

In making repairs to metal pilots the cutting torch is employed extensively in separating the structure, for if the rivets are cut off with sledge and chisel, on account of the light material, a decided loss would ensue through damage caused in cutting off and backing out rivets. Fig. 4 shows a pilot, on which the rivets have been cut off, ready to be dismantled and straightened. We also manufacture in this department tanks, foundry ladles, structural shapes, etc. Welding is employed wherever possible instead of riveting and other methods of joining the metal parts. One or more welding outfits are in constant use in this shop.

General Boiler Welding

Boiler work develops an extensive field for both the oxyacetylene and arc welding processes. When the inside firebox must be removed, instead of cutting it out as we were formerly forced to do with drills, hammers and chisels, the oxyacetylene process is now employed. The work is performed not only quicker and cheaper but with less hard labor and with more satisfactory results. In fabricating the new firebox to replace the old one removed, we find that numerous irregular shapes are needed. Formerly the trimming of these sheets was performed under the power punch. They are now cut with the oxyacetylene torch which reduces the cost and saves considerable time.

The question of whether the welding together of all the sheets in the firebox is better than the riveted process is now under consideration. We have partly welded fireboxes now in service and their performance so far is all that could be expected and we believe that by employing the long flange so that the weld is made between two rows of staybolts, almost perfect results can be obtained. The welding of these seams can be performed with either the oxyacetylene or electric arc process.

In removing the mudring from the boiler we very often find the bottom of the ring in poor condition due to corrosion. The sharp corner of the mudring in many instances is eaten away. We build up the corners and all flat surfaces where corrosion has taken place. Such a job is shown in Fig. 5.

After the inside firebox is removed from the boiler the staybolts still remain in the outside wrapper sheet. To remove these bolts the oxyacetylene torch is employed to turn the bolt half way through the sheet; the bolt is then hot enough in the sheet so that it can be worked out by a helper who uses a short length of pipe for this purpose. This method of removing staybolts from side sheets is fast and is an improvement over the old method of drilling them out.

Application of Flexible Staybolts

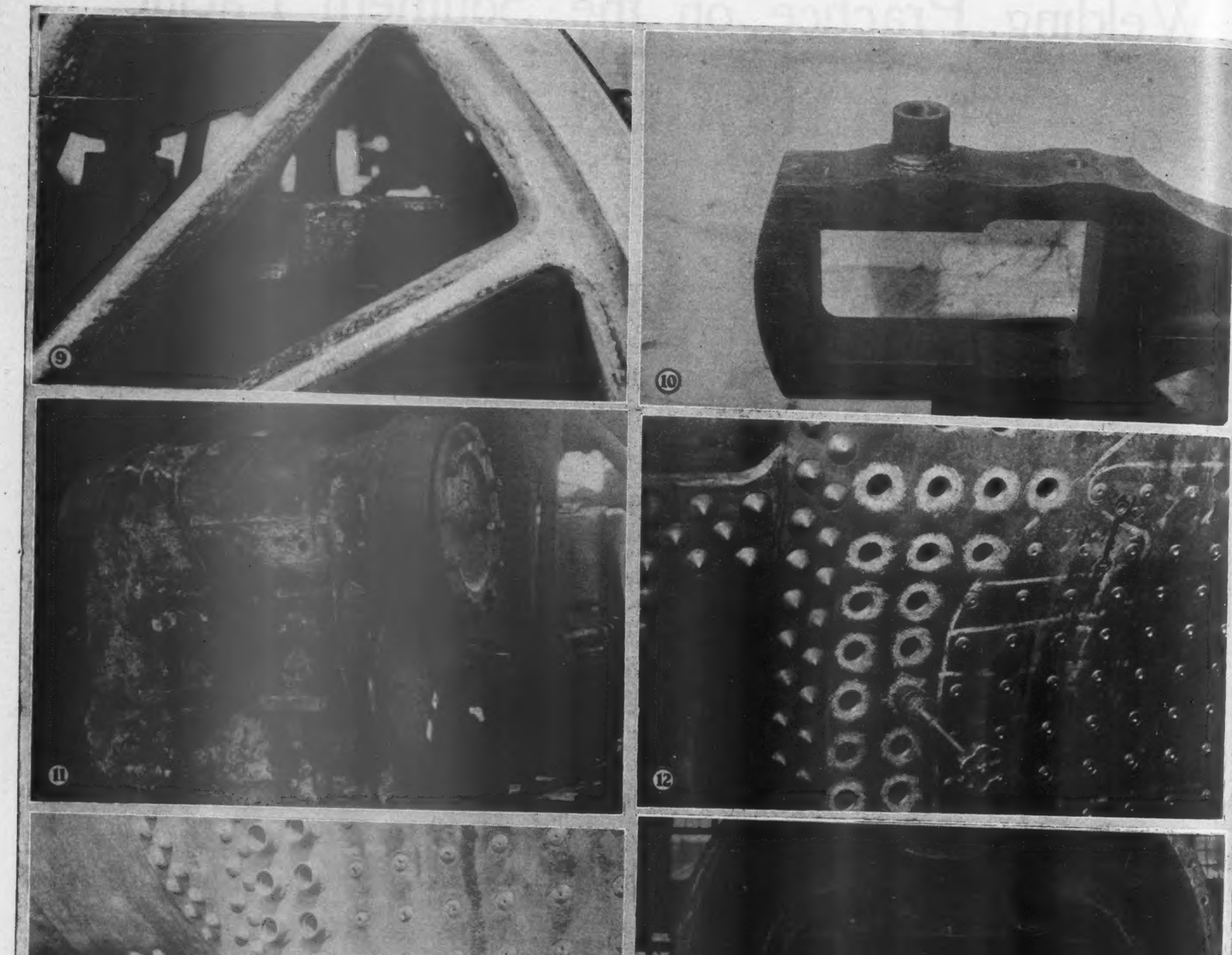
We apply a great many flexible staybolts to locomotive boilers. The sleeves were formerly screwed into the outside wrapper sheet but this is relatively an expensive operation. The new style sleeve is ball seated and welded to the wrapper sheet by the electric arc process. The oxyacetylene process could not be employed on this class of work as on account of the diffused heat, the sleeve and sheet would have a tendency to warp. A particularly advantageous feature of the electric arc weld is afforded through the concentration of the intense heat in a small area enabling it to be applied just where it is needed without heating up so much of the adjacent material.

In welding firedoor seams the practice of some roads is to prepare the door hole seam as ordinarily done for plugs or rivets and then lap weld the flange to the back head. The method followed by the Southern Pacific is to butt the flanges of the back head and door sheet, and weld with either the electric arc or oxyacetylene process. We have been following this process for several years and have never experienced any trouble with this method of welding door holes.

When the bottom of the tube sheet is badly corroded and cracked it can be repaired. If the welding process was not available we would find it necessary to remove the entire sheet, which would cause considerable delay and add greatly to the cost of making repairs to this boiler. The repairs are made by cutting out the lower section of the sheet, leaving the dry pipe and header in place and welding in a new section.

Defects that develop in the firebox sheets are repaired with

*Abstract of a paper presented before the San Francisco section of the American Welding Society, by H. J. McCracken and F. J. Hickey.



Specimens of Welding Work Done in the Southern Pacific Shops at Sacramento

both oxyacetylene and electric arc processes where new half side or tube sheets are applied. The defective parts are cut out with the oxyacetylene torch and the electric arc is employed almost exclusively in welding in the sheets.

Another operation in which the electric arc has been employed to great advantage in railroad shops is in the maintenance of boiler tubes. Tubes are applied in the boiler in the usual manner and placed in service. After they have been in service a certain period or when they show signs of leaking the locomotive is held and the tubes are given a thorough working, then the sheets are roughened or sand blasted and the tubes welded to the sheet. We find this method has given excellent results.

There are many other articles repaired in the boiler shop by the electric arc and oxyacetylene processes. An example is a bail for a dragline bucket. This bail came in the boiler shop broken in several places. We applied a 1-in. reinforcing plate on the bottom side and welded it all around on inside and outside edges with the electric arc process, thus insuring a strong durable job which will stand up to the heavy service imposed upon it.

Machine Shop Welding

Among the many parts repaired in the machine shop are trailer truck equalizers, transmission bars, eccentric cranks, cross heads, coupler supports, truck frames, draw bar yokes, chafing iron castings, radius bars, truck spring hanger pins, eccentric blades, links, guide yokes, ends of axles, swing hangers for pony trucks, center castings, end sills for tender frames, cylinder head castings, injectors, piston rods, cylinder heads, superheater units, reverse shafts, dope cups on rods, cylinders, piston heads and axle collars.

Reclaiming Castings in the Foundry

In the steel foundry where many castings are manufactured every day, broken and defective castings can be reclaimed by welding those that are found defective from sand spots, blow holes or shrinkage cracks. These welds when properly made are as readily machined as any other part of the work. Risers and sink heads can be cut off quickly and more cheaply than by any other method.

Fig. 6 shows a method of welding high speed steel points on carbon steel lathe tools, which gives very good results and saves making the whole tool out of expensive high speed steel.

Figs. 7 and 8 shows a worn outer collar of car axle before and after reclaiming with the electric welding process. By machining the collar to the original thickness the axle is ready for use again. It would otherwise have to be scrapped.

A locomotive frame that had broken and was welded with electricity is shown in Fig. 9. This is a very good illustration of the saving that can be made by using the oxyacetylene or electric welding processes. Formerly with a break of this kind it was necessary to drop the wheels and do considerable stripping before the frame could be welded. This weld was made with the arc without doing any stripping or disturbing the driving wheels. We have had very good success with welds made in this manner. The material is cut out with an oxyacetylene cutting torch, trimmed up by hand and then electric welded; either solid weld or laminated process.

A grease cup welded on a locomotive main rod is shown in Fig. 10. The cup is finished in a turret lathe and set over the hole in the rod, welded and then smoothed up with a hollow mill. After finishing the cup has the appearance of having been made integral with the rod. An electric welding job on a cracked locomotive cylinder is shown in Fig. 11. The break is veed out and studs applied in sides of crack and then filled up solidly with the electric welder.

Patches in boilers now welded in place were formerly applied with rivets or plugs and the joints very often interfered with other parts of the machinery. The welded joint overcomes that difficulty, the seams being practically the same thickness as the sheet.

Fig. 12 shows the preparation and method of holding sleeves while welding, and Fig. 13 shows flexible staybolt sleeves welded on a locomotive boiler. After the holes are drilled and countersunk to suit sleeves the surface surrounding the holes is cleaned and roughened, which breaks away all scale and dirt on the sheet and gives the welder a chance to do a much better job than would be possible if roughing was not done.

Both superheater and small flues are electric welded around the beads, which method we have been following in all our shops for some time with very satisfactory results. There has been little basic improvement made in the method of applying and setting flues for the past 30 years or more, and flues will leak, very often causing delay to a train.

Welds across the center of front flue sheet on 2-10-2 class locomotives are shown in Fig. 14, the lower portion of the sheet being new.

A method of applying a patch to the top of a door sheet is shown in Fig. 15. The patch was necessary on account of lap cracks and because the sheet was pitted in the knuckle. This patch as shown has been tack welded in several places in order that bolts and clamps may be removed. The same door sheet after welding is shown in Fig. 16.

Welding at the Reclamation Dock

Many parts are reclaimed on the reclamation dock with oxyacetylene welding, such as switch points, frogs, couplers of all sizes and types, coupler knuckles of all types, continuous rail joints, track drills, switch stands, oil cups, water strainers, spring plates, steam hose couplings, pipe cutters, monkey wrenches, oil drums, ballast forks, body bolsters, truck bolsters, journal boxes, track jacks, brake heads, etc.

The most successful applications of welding undoubtedly have been in places where thorough supervision and training of welders have been carried on. No matter what kind of material is to be welded, or what the type of welding is, the reliability of the weld rests in a large degree with the operator.

Careful examination and inspection of the welded joint is of the utmost importance. There are certain factors which determine the physical characteristics of the weld: First—examination of the weld by visual means; second—the edges of the deposited metal should be chipped with a cold chisel or tried with a calking tool to determine the relative adhesion of deposit; third—pulling apart welded sections cut from the finished product; fourth—the bending or breaking test.

Condition of Power Hammers Important*

THE variations in steam consumption for a given size of steam power hammer depend entirely upon the condition of the hammer, relative to its state of repair and valve adjustment. In order to get the most economical operation, all valve rigging should be in the best mechanical condition. In order to obtain this, special attention must frequently be given to all bushings and bolts to keep them tight. Valves must have a good fit in the valve cases, but must not be too tight to hinder operation of the hammer.

Another very important item is the condition of the cylinder and piston rings. It takes a very short time for a cylinder to become larger in the center than at either end, particularly if lubrication is not the best. In our plant we obtain very good results by using a packing ring rather

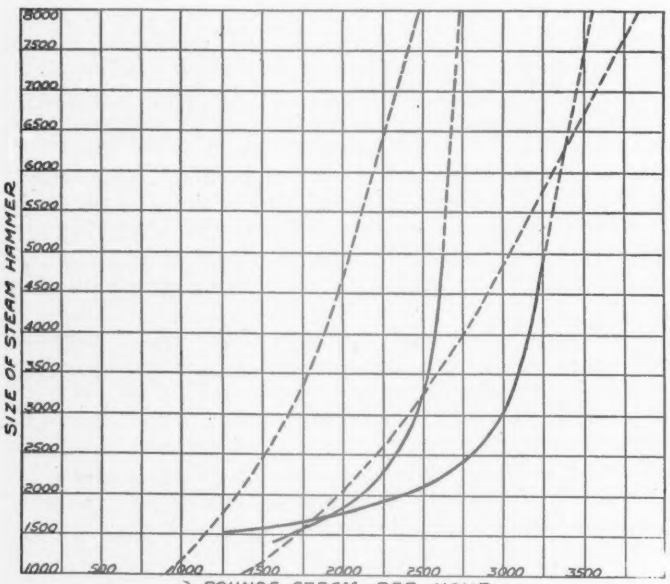
*From an article by R. E. Waldron, chief engineer, Dominion Forge & Stamping Company, Walkerville, Ontario, published in October, 1922, Forging and Heat Treating.

than a metallic ring. We have used steel and bronze rings, but finally came to the packing ring, which has given us entire satisfaction and we use it on every hammer in the shop, with the result that we have not had to touch a cylinder for over three years. The method of installing these rings permits at all times a very good contact throughout the circumference of the cylinder, thus eliminating to a great extent leakage of steam past the piston. You are probably all familiar with this piston ring; however, there are several on the market, and we find some which give much better service than others.

The correct adjustment of the main valve is a very important point for the master mechanic or repair man to keep in mind at all times, as it is quite possible to have the valve set in such a way that the hammer will operate very satisfactory, but with the operation far from economical. The valve setting question is one which is handled by every master mechanic in his own way and which is really a difficult point to keep checked up. However, you can tell a great deal about the setting and condition of steam hammer valves and rings by studying the exhaust and by watching for a good sharp cut off.

Steam Consumption Per Hour for Various Sizes of Hammers

Four curves to show steam consumption per hour for various size hammers from 1,000 to 8,000 pounds are given

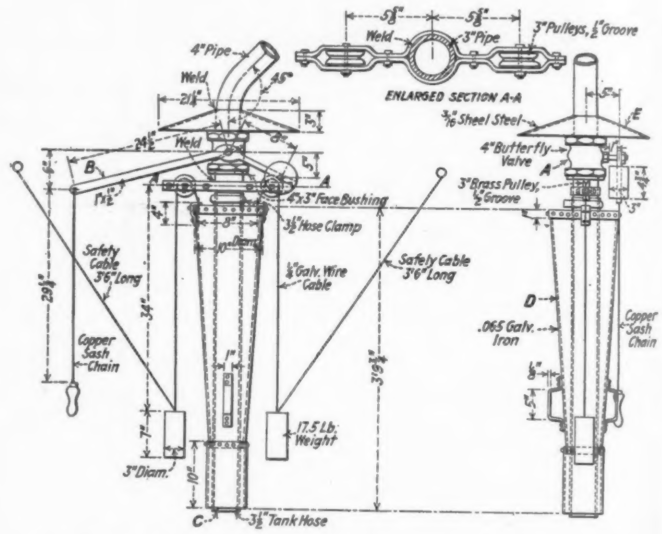


Steam Consumption of Steam Drop Hammers. Curves Plotted from the Results of Four Sets of Tests to Show the Steam Consumption Per Hour for Various Size Hammers

in the illustration. You will see that there is quite a difference between the results of these various tests. The two full dotted curves were taken from Messrs. Craig and Thompson's article in the Iron Age of June 9, 1921, showing consumption of hammers in good repair and the same hammers before putting them in good condition. The great importance of keeping hammers in good repair is evident. The third curve is plotted from figures which were obtained by a series of tests run by another forge shop which has done considerable work upon this problem. The fourth curve is one which was plotted from figures obtained from actual tests in our own shop. These tests were all made by actually condensing the steam from exhaust and weighing the condensate. You will see that they vary considerably, but as I stated before, this depends entirely upon the condition of the hammer.

Sand Valve and Telescope Pipe for Sanding Locomotives

PRACTICALLY every coal dock and enginehouse is equipped with a sand box filling device, but some of these give trouble. The one shown in the illustration has proved unusually efficient for sanding locomotives quickly and to date has required no expenditure for maintenance. The telescope arrangement permits large and small locomotives to be sanded without spilling sand over the jacket, allowing this sand to find its way into the machinery, where it causes endless trouble. This device has been in service



A Cheaply-Made and Efficient Locomotive Sanding Device

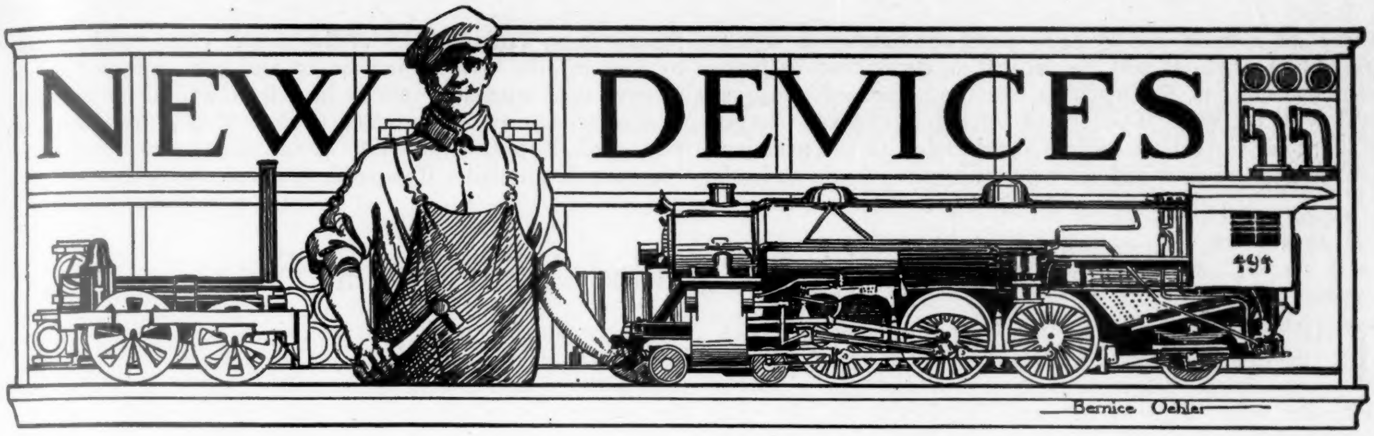
over 18 months and has given no trouble whatever during that period.

Sanders of the type illustrated are elevated on the coal dock, one being provided over the center line of each track, just high enough to give a little clearance over the largest locomotive. Each sander is applied to a 4-in. pipe extension from the sand storage tank, usually elevated in some high portion of the coal dock, so that the sand can work down by gravity.

Mechanical Construction

This sanding device consists of a 4-in. extra heavy butterfly valve *A*, provided with a 1-in. valve stem and operated by a counterbalanced lever *B* which makes the valve self-closing. A 3½-in. tank hose *C* about 3 ft. 10 in. long, is clamped to a 3-in. pipe nipple and applied to the bottom of the sand valve *A*. A galvanized iron pipe *D* is suspended over two pulleys and counterweighted, safety cables being provided as shown. Details of the arrangement for supporting the pulleys are shown in section *AA* and the proportions and length of cable are such that pipe *D* has a 34-in. adjustment over tank hose *C*. Two handles on pipe *D* provide for its easy handling. A copper sash chain with a suitable handle serves as an extension to operating valve handle *B*. A large sheet metal hood *E* is welded to the 4-in. pipe above the sand valve to protect the device as much as possible from weather conditions.

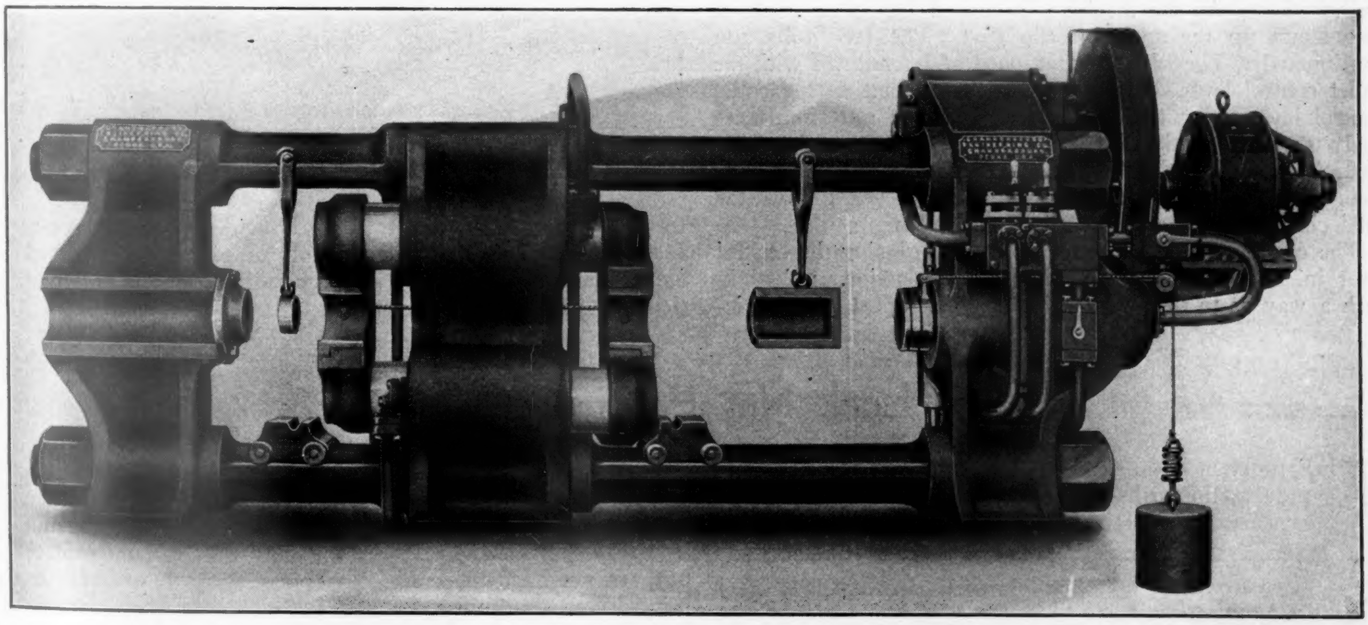
It is not necessary to spot locomotives on the center line of this arrangement, as the sheet iron pipe *D* permits a 24-in. adjustment in all directions from the center line. With proper care in constructing and assembling parts, this device will operate successfully for an extensive period without need of repair.



Mounting and Demounting Car Wheel Press

SIMPLICITY, ease of control and speed of operation are predominating features of the new No. 476 Chambersburg wheel press illustrated. This press is designed for mounting and demounting car wheels, being notable for few moving parts, stationary beams and single motor drive. The press is built in two sizes, one having a capacity of 200 tons for mounting and 400 tons for demounting; the other size provides 300 tons for mounting and 600 tons for demounting.

With this press, both wheels can be pressed on or off an axle simultaneously or one at a time. The press is automatic in operation, being designed for severe duty and the reduction of maintenance and repair to a minimum. All beams are stationary and have large bases, enabling the press to be bolted directly to a concrete foundation. All necessary adjustments for pressing on or off wheels are made by means of small light forcing blocks and sleeves suspended from a trolley. The cylinder beam at the right-hand end contains the ram for pressing wheels on their axles. The center beam is used for pressing wheels off. The rams have a long bearing in the beam and are provided with safety valves so that when the plungers reach an outward stroke of 12 in., the valves blow off, preventing over travel. The resistance beam at the left-hand end is provided with a removable steel facing head and is recessed to permit long shafts to be readily handled in the machine.



Simplicity, Ease of Control and Speed of Operation are Features of this New No. 476 Chambersburg Wheel Press

Two independent pumps mounted in one body are attached to the right end beam. The eccentric drive shaft and plungers are run continuously from the motor mounted on the press. When the conveniently-located operating valves on the front of the press are open, the discharged water is bi-passed to the supply tank. When either of these valves is closed the water is forced to the operating cylinders. The large plungers on each side of the pump have a release valve so that when a pressure corresponding to about 100 tons on the rams is applied, these release valves open and bi-pass water from the large plungers. The small plungers continue pumping until the maximum tonnage is reached, when a second set of release valves opens preventing an excessive pressure. Valve trips are provided on the pumps so that a variety of speeds can be obtained on the rams.

The rams are of modern construction throughout so arranged that they return rapidly after each stroke and without the loss of water. This press can be arranged for either belt or motor drive as desired. A 20-hp. motor, running at 900 r.p.m., is required for the 200-400-ton press; a 30-hp. motor for the 400-600-ton machine.

In addition to the complete press, two assembling

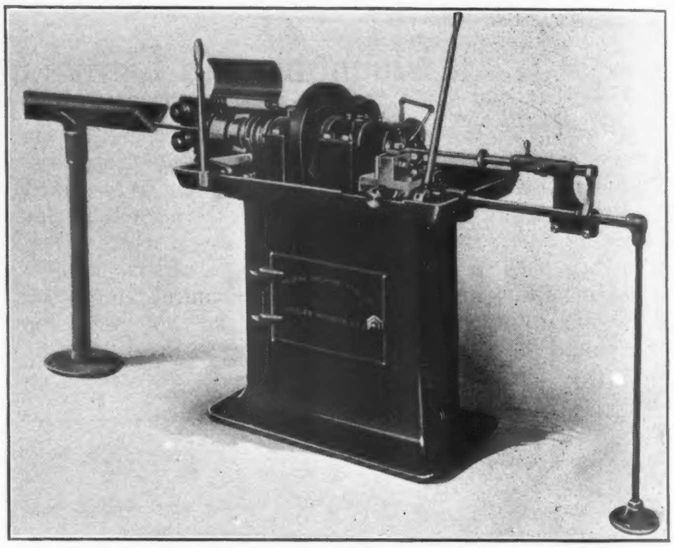
trucks on a track and a screw jack are furnished. These assembling parts should be located a convenient distance from the front of the machine, the truck grooves being set level with the floor. One set of forcing blocks and sleeves is supplied, carried on trolleys furnished with the machine. Two trucks are provided for supporting the wheels and adjusting them longitudinally in the press. These trucks serve to line up the wheels and axles and are equipped with grooved caps spaced to suit 33 in., 36 in. and 38 in. wheels. The pressure gage is graduated to show tons pressure on the rams and lb. per sq. in. This press is made by the Chambersburg Engineering Company, Chambersburg, Pa.

Cutting-Off Machine Provided With Roller Feed

THE machine for cutting off pipe, tubing and solid bars, made by the Modern Machine Tool Company, Jackson, Mich., has recently been provided with a double live roller feed. This arrangement, applicable to 2-in. and 3-in. machines, feeds the stock through the spindle against an automatic stop for gaging the length of pieces to be cut off. The automatic stock stop is of the same general design as the old one, but is operated from the tube block. A plate, adjustable to take care of the tool setting for different sizes of stock, is attached to the right-hand side of the tool block and arranged with a lug to catch and rock the rocker block shown between the tool block and frame. As the tool block is moved out, removing the tool from the cut, the last 1/8 in. movement, the lug catches the rocker shaft and, through the lever and cam, rotates the stock stop throwing it out 3/16 in. As soon as the tool block is fed in to start the cut, the spring brings the stop back to place clear of the work so that it will not wear and the work can drop away from the tool.

The double live roller feed for feeding stock through the spindle is driven through worm and gears from the cone pulley shaft. As the machine is slowed for large stock, it also slows up the speed of the feed. The feed rolls run continuously. They are so trunnioned and connected with the collet control lever shaft that the in-movements of the collet control lever opens the collet and brings the roll simultaneously up to the stock. A slight further pressure on the collet control lever feeds the stock through the spindle against the stop. The back movement of the collet lever throws the rolls clear of the stock and closes the collet.

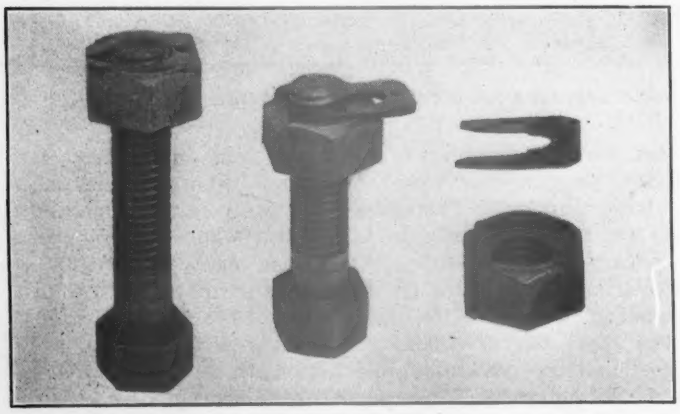
The collet control has been changed by placing the control lever in a vertical position, with a toggle action applied in such a way as to do away with the greater part of the friction encountered on the old machine. The collet control lever operates a great deal easier than on the old machine even with the added work of controlling the feed. Moreover, the operator is saved three or four motions and one step for every piece he cuts off. This is evidently an important factor in working up large amounts of piping or bar stock as frequently is necessary in large railroad shops and particularly production departments.



Modern Machine for Cutting Off Pipe, Tubing and Bar Stock

Safety Lock Nut Positive in Action

THE problem of lost nuts is one of considerable magnitude to the railroads and represents a large item of expense for replacement and damage to other parts of the equipment due to nuts working off in service. Several notable features are evident in the design of the safety lock nut illustrated. The nut is positively locked in any position desired on the bolt and cannot get loose from vibration, remaining firmly in place until removed by hand. The nut is easy to put on and take off and the threads of the bolt or nut are not destroyed unless it is attempted to remove the nut without first unlocking the patented pin. As shown in the illustration, the face of the nut is milled to receive the patented pin which has two points fitting around the bolt. There is a shoulder on each of these points and a small hole in the body of the pin.

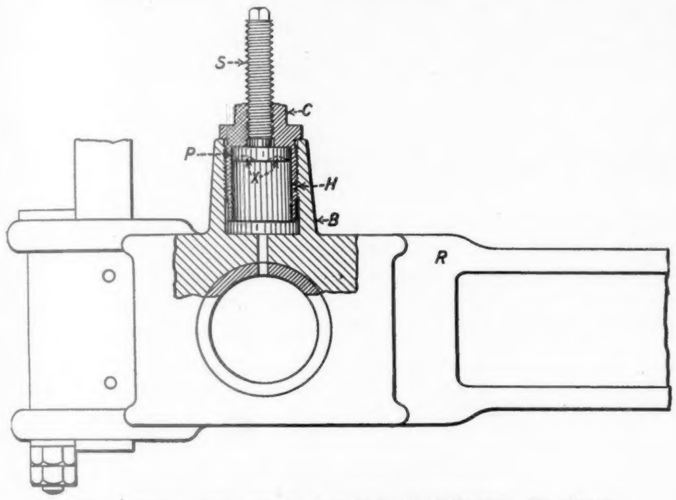


Rose-Albin Safety Lock Nut

In putting this nut on, it is turned down as far as it will go. The patented pin is driven in the slot in the nut as far as it will go until the butt end is flush with the side of the nut. The points are then pulled together as illustrated at the left in the illustration. The success of this nut depends upon the two shoulders of the patented pin digging into the thread of the bolt just enough to nick it. This does not destroy the threads unless a wrench is used to turn off the nut before first unlocking the patented pin. In removing the lock it is simply necessary to straighten the points of the pin and use a punch in the small hole indicated. This patented nut can be locked in any position on any thread. It is made by the Rose-Albin Safety Lock Nut Company, Brooklyn, N. Y.

Grease Cup for Locomotive Connecting Rods

A GREASE CUP for locomotive connecting rods, so arranged that it is not easily lost nor the threads stripped or crossed, is shown in the illustration. Grease cups sometimes are arranged with an extension threaded to turn into a suitable hole in the rod, but in this case the boss *B* is forged integral with the rod *R*. The grease cup *C*, provided with an integral nut portion at the top for application and removal, consists essentially of a cylinder in which plunger *P* is operated by screw *S*. It will be noted that the oil cup has a long threaded bearing in boss *B* and a considerable extension at the lower end, of the same diameter as the root thread diameter. This assists in starting the cup on application and practically prevents all possibility of cross threading. Two recesses *X* are shown in plunger *P*. These act as keys for the grease and tend to prevent accidental turning of the plunger. A small hole *H* is drilled near the bottom of the grease cup but above a few threads to allow hot gases, if such are formed, to escape before the plug is completely removed. This prevents boiling hot grease from being blown around as sometimes happens with solid plugs.



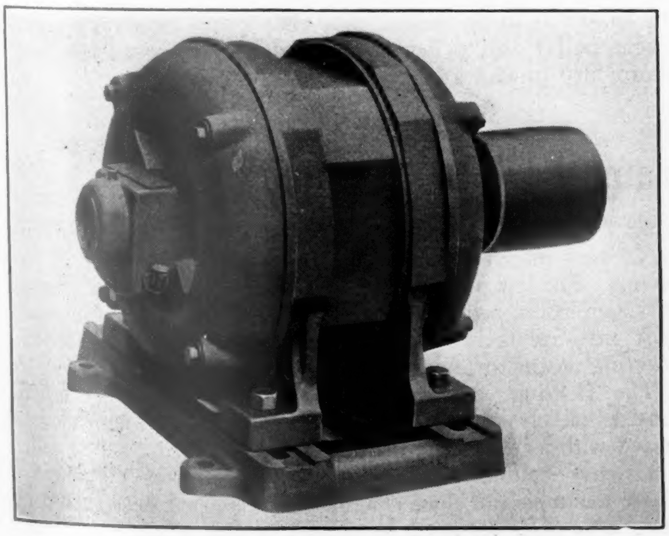
New Grease Cup with Several Meritorious Features

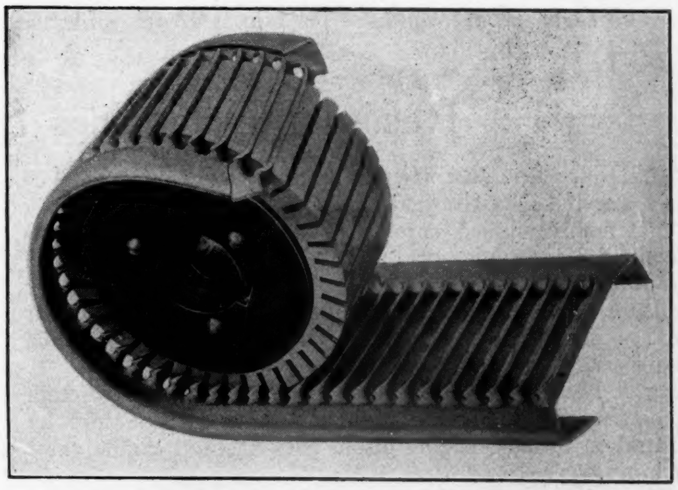
In operation, this grease cup is unscrewed from the rod and the plunger turned to its upper position. The cylinder is filled with grease and the cup re-applied to the rod. Turning the screw *S* then forces grease into the bearing as desired. The boss itself does not receive grease so that threads in the boss are never clogged, another fact which decreases the possibility of crossing and stripping the threads. No locking nut is needed because the shoulder on the cup contacts with the top of the boss and locks the cup in position when it is screwed down tight. As the cup is threaded over the major portion of its length there are sufficient threads so that the cup may be screwed down tight into place without danger of stripping the threads.

The advantages of this form of grease cup construction over that commonly used will be apparent at a glance. The cup has been given a severe test by several western roads under adverse service conditions and proved satisfactory. It is said that an engine in passenger service equipped with these cups ran 2,000 miles with one filling. J. W. Warden, Autocall Company, Shelby, Ohio, controls the patent.

Induction Motor with One-Piece Rotor Winding

A NEW induction motor, designated as L-A type H. D., and having a one-piece rotor winding, has recently been marketed by the Louis Allis Company, Milwaukee, Wis. The entire winding of the motor consists of an integral sheet of copper, punched and formed by a special mechanical process. This one-piece winding is machine-wrapped around the rotor core, the copper bars being expanded into the core slots by swaging.


Louis Allis L-A Type H. D. Induction Motor


Rotor Winding Made of One Piece of Thin Copper Stock

The single joint which extends through the two end rings is silver welded, after which the metal at both connections is processed by means of a contracting operation that rehardens the copper at the point where the heat, applied during the welding, softened it. This treatment results in a lapped, silver-welded joint of high strength.

The rotor winding is fabricated of comparatively thin copper stock, which has a high thermal conductivity and which conducts the heat generated in it toward the ends of the rotor bars where this heat is dissipated through the action of the malleable iron fans. The rotor bars themselves also constitute an efficient blower, thus materially increas-

ing the ventilation. The rotor core is a self-contained unit and may be pressed on and off the shaft readily, as it has a straight keyway.

In other respects the motor is largely conventional except that it employs open slots without the usual overhanging tooth tips. The manufacturer's experience has shown that so long as a suitable relation is maintained between the air gap and slot width, the performance does not suffer as regards power factor and efficiency, and that a rotor core of this construction, with a suitable winding results in exceptionally high starting and running torques. These abnormally heavy starting and running torques have led the manufacturers to increase the shaft size over and above the usual practice for a given rating which, in combination with the liberal bearings, fabricated from a phosphor bronze, should insure long life in service.

All motors are guaranteed to carry their full rated load continuously with a temperature rise not exceeding 40 deg. C., and after their ultimate temperature has been reached, to carry 25 per cent overload for two hours with a temperature rise not exceeding 55 deg. C. The motors are made in standard industrial sizes, voltages and frequencies.

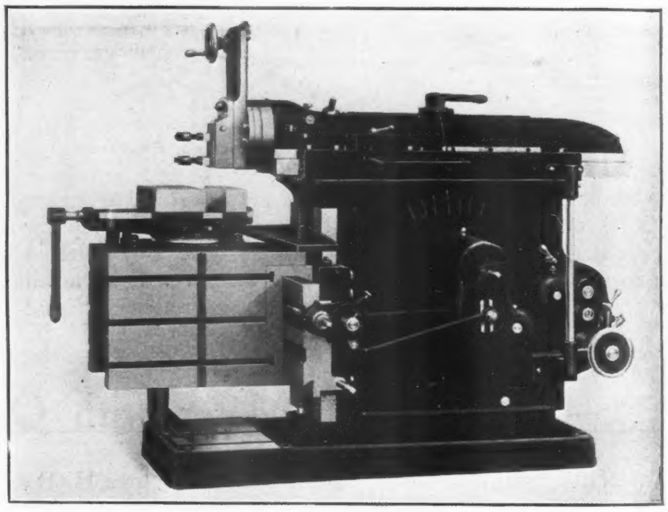
Rugged Shaper With Thirty-Two Inch Stroke

A RUGGED shaper, known as the Dreadnaught, has recently been developed by The Ohio Machine Tool Company, Kenton, Ohio. The column, rail, ram and in fact all of the important parts of this shaper have been designed with generous proportions in order to meet the requirements of large plants where the work is particularly severe and where the shaper is not only required to remove metal rapidly and accurately, but to take a maximum cut at each stroke without stalling.

The Dreadnaught shaper has a stroke of 32 in. and is equipped with a large diameter pulley, having a wide face, which will efficiently transmit all the power required. The single and back gear ratios, as they denote the relation between the revolutions of the drive pulley and stroke of the ram, furnish further evidence of the power the machine can deliver, everything else being equal. The back gear ratio of this machine is 28 to 1, unusually high for a machine of this character.

The power in a crank shaper is transmitted from the gearing to the crank arm and thence to the ram and cutting tool; the higher above the center of the crank arm the center of the bullgear can be located, the greater the power delivered on account of the increased leverage. It is, therefore, advisable that the crank arm be as long as possible consistent with correct design and in the Dreadnaught shaper it is 42½ in. long. This, coupled with the high back gear ratios and large driving pulley, make this shaper especially desirable for "hogging" work. The ram bearing cannot wedge into the column bearing because it is square, flat and sufficiently high to resist the pressure exerted. This bearing is 2½ in. high and the width of the ram is 13 in. while the length of the ram is 62 in. not including the tool box. The outside diameter of the front end of the ram is 11 in. Provision is made so that even on extreme strokes a great proportion of the ram remains in contact with the column bearing.

All the control levers are located on the operator's side of



Ohio Dreadnaught Shaper Designed for Heavy Duty

the shaper, thus permitting quick setup and adjustment while the shaper is in operation. The shaper can be arranged for single pulley belt drive or motor drive. Power down feed is provided as an extra attachment.

Recorder Determines Steam Turbine Economy

THE Uehling Instrument Company, Paterson, New Jersey, has just developed and placed on the market a new combined barometer and vacuum recorder primarily for determining (1) the absolute back pressure in steam turbine and condensing plants, (2) the barometric pressure, (3) the condenser vacuum, (4) the existence of air leakage into the condenser, etc., and (5) the ability of the condenser to handle the load.

High back pressure is caused by air infiltration through condenser shells, exhaust piping, turbine casings, and by infiltration through engine piston packings and engine valve packings.

The existence of an unnecessarily high back pressure represents a waste in turbine steam consumption that is astonishing. In fact this waste is ordinarily larger than all the other power plant losses combined, with the exception of the heat lost up the chimney due to low CO_2 in the products of combustion. For example, for a high pressure turbine, the relative steam consumption of the turbine per kw. hr. increases 16 per cent as the absolute back pressure increases from 1 to 4 in. of mercury (corresponding to a diminution in vacuum referred to a 30 in. barometer of from 29 in. to 26 in.). For low pressure turbines the corresponding increase in steam consumed per kw. hr. is 50 per cent. Absolute back pressure is indeed one of the most important factors affecting steam turbine economy.

The Uehling combined barometer and vacuum recorder consists merely of two float chambers, one of which is connected with a barometric mercury column, and the other with a mercury column in communication with the condenser. These columns and float chambers are secured to a recorder case, with pens actuated by means of floats resting on the mercury in the two chambers. The movements of the floats correspond exactly to the changes in barometric pressure and in vacuum.

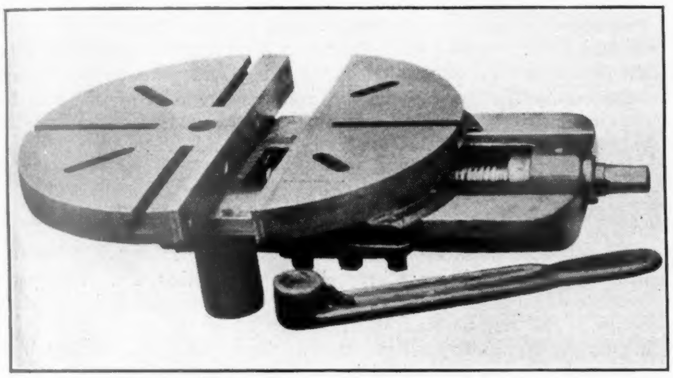
The recorder draws automatically and continuously the barometer and vacuum records on the same chart. If the vacuum falls when the barometer remains constant, either considerable air is leaking into the condenser, or the condenser is not able to handle the load.

Advantages of Baush Metal Duralumin

Mechanical engineers are watching with a great deal of interest the development of a new aluminum alloy known as Duralumin. This alloy is now being manufactured by the Baush Machine Tool Company, Springfield, Mass., under a license from the Chemical Foundation. The advantages claimed for Duralumin are high resistance to corrosion under adverse weather conditions and an unusual combination of strength and lightness. The alloy has a tensile strength and physical properties approaching those of mild steel but weighs only about one-third as much as steel sections of the same size. At the Baush Machine Tool plant, this new alloy is rolled into sheets, forged, fabricated and heat treated the same as steel, being used for a large variety of purposes. Applications have been found for its use in over 100 industries including the railroad industry. It is understood that at least one prominent western road is experimenting with this material for car doors and if used for locomotive motion work there should result an appreciable decrease in dynamic augment. The cost of manufacturing it as now produced is so high as to confine it practically to the automotive field in which high premiums are paid for the combination of light weight, strength and resistance to atmospheric action. As the methods of production are improved, however, it is quite possible that the cost may be decreased so that it will be economical to use Duralumin in the construction of certain parts of cars and locomotives.

Combination Drill Table and Vise

Arranged to fit any drill press, the combination drill table and vise illustrated has been placed on the market by the Modern Machine Tool Company, Jackson, Mich. This vise is now made in two sizes, the



Modern Drill Table and Vise Saves Time, Drills and Spoiled Work

diameter of the table closed being 16 in. and 19 in. respectively. The latter size is made for use on 20-in., 21-in. and 24-in. drill presses. The 16-in. vise opens at the jaws 8 in. and the 19-in. vise 10 in. Either vise fits in the regular drill table socket and swivels the same as the regular table. It will turn over ¾ of a revolution and when opened forms a large handy vise. The vise jaws are faced with machine steel (hardened if desired) and are made interchangeable so they can be replaced at any time without trouble in fitting. The vise screw is of ample proportions and runs in a bronze nut. The ways are carefully machined. The table has four T-slots and is machined for accurate work.

The advantages of this device are the saving of time, drills, material and the prevention of accidents. The operator wastes no time hunting up a vise or bolt, bolting the vise to the table and removing it from the table when the job is finished. Drills are not broken due to the work slipping, as frequently happens with clumsy clamping devices. The combination drill table and vise clamps each piece securely and instantly into the proper position for drilling, thus tending to eliminate spoiled work and also prevent accidents. The vise opened forms a split table where work with projections can be drilled without the use of parallels. With the vise opened a small amount, a vee is formed, enabling shafts and round work to be drilled readily.

Simplicity Features New Valve Design

A new type valve, known as the "Flatplug" valve, is being manufactured by the Everlasting Valve Company, Jersey City, N. J., and distributed by the Scully Steel and Iron Company, Chicago, Ill. The valve includes all the more important features of the "Everlasting" type and, in addition, has advantages not incorporated in former types.

The valve seat, which is rectangular in shape, fits into the bottom bonnet on a circular gasket joint. It is held in place here, as may be seen from the accompanying illustration, by the pressure and a stiff spring. The disk, which is cup-shaped, has a sliding contact with the seat at all times. The disk is also held to the seat by the same spring.

In the view of the valve in the left of the illustration the fluid is shown flowing past the cup into the uncovered openings in the seat and so to the outlet. The second view shows the valve in the closed position.

In assembling, the seat is merely pushed into place by hand, no screw threads or other form of fastening being necessary. When taking the valve apart, the seat is removed by pulling it out of the body without the use of tools. When the valve is in its normal position, or on either side or end, the seat will not fall from place; for when assembled it is held in place by the disk and spring.

In order to make repairs, it is only necessary to remove the top bonnet and all parts are readily accessible. New

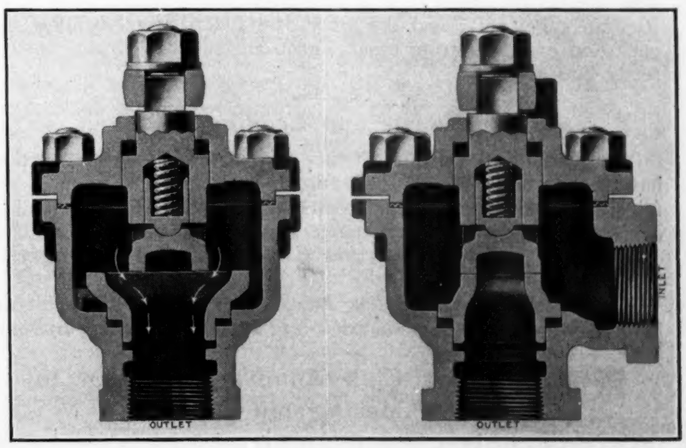


Fig. 1—Valve Open, Fluid Passing Into Uncovered Openings in Seat (left). Fig. 2—Valve in Closed Position

parts for replacement may be installed without removing the valve from the line or disturbing the piping.

GENERAL NEWS

B. H. Meyer has been elected chairman of the Interstate Commerce Commission to serve for one year from January 1, 1923. He has been a member of the Interstate Commerce Commission since January, 1911, having been appointed by President Taft.

The Central of Georgia has extended the benefits of its pension plan to include the shopmen. The announcement of President Winburn, giving this information, says that under former conditions the benefit of the pension arrangement could not be conferred on the shopmen because their unions objected to physical examinations.

The New York Central reports the heaviest fall of snow in New York State since 1874; but passenger trains have been kept moving with only moderate delays. Freight locomotives, however, have been able much of the time to haul only 75 per cent of their normal loads. At times 100 locomotives have been at work in ridding the tracks of snow.

The Chicago, Rock Island & Pacific has decided to abandon the use of coal for locomotive fuel in both Arkansas and Oklahoma, and to convert its locomotives in that district into oil burners. Locomotives on the Louisiana division are already being converted and the change will be made in others as soon as possible, according to the plans of the operating officers.

The Associated Employees of Beech Grove, Inc., an incorporated organization of employees of the Cleveland, Cincinnati, Chicago & St. Louis locomotive shops at Beech Grove. Ind., which are now operated under the supervision of the Railway Service & Supply Corporation, have united with that corporation in a suit against the Railroad Labor Board. The employees' organization in their petition assert the rights of the majority at Beech Grove were ignored by the Labor Board when it handed down its decision restraining the road from contracting for its shop work at Beech Grove and Brightwood, Ind.

British Railway in Argentina Orders 340 Cars

The Central Argentine Railway, a British-owned line, has ordered 200 all-steel, high-side gondola cars and 140 all-steel box cars from Cammel, Laird & Co., the English car builders.

Germans to Rebuild Moscow-Minsk Railway

The Soviet military authorities have arranged with German engineers for the reconstruction of the Moscow-Minsk railway line, according to the Times (London). Minsk is on the Polish frontier. The line, as rebuilt, will be double track, one of which will be of Russian gage, 5 ft., and the other of standard gage to allow the operation of trains from other European countries to operate directly into Moscow.

Interchange and Loading Rules

The Mechanical Division of the American Railway Association has recently announced that because a considerable number of refrigerator cars have not yet been equipped with brine retaining devices as required by Interchange Rule 3, Section s, the effective date of this provision of the rule has been extended to January 1, 1924.

The Interchange and Loading Rules as revised in 1922 have now been issued and may be obtained from the secretary of the division.

Pacific Railway Club Admits Supplymen to Membership

The Pacific Railway Club, the only railway club in the country that has not admitted supplymen to membership, amended its constitution at its November meeting and supplymen will hereafter be admitted to associate membership upon the same basis as they are admitted to other clubs. Supplymen will pay the same dues as other members, $3 a year, but may not vote or hold office. There is no initiation fee.

Another Electrification Combine in Britain

An agreement is rumored, according to The Engineer (London), between Sir W. G. Armstrong-Whitworth & Company, locomotive builders, and the British Thompson-Houston Company, electrical manufacturers, whereby the former will undertake to build electric locomotives and rolling stock and the latter electrical equipment, power stations, etc., for railway electrification. Two other strong groups similarly organized already exist in England, viz., the Vickers group and the Power & Transport Finance Company, which is backed by the North British Locomotive Company and the English Electric Company.

I. C. C. to Investigate Railway Efficiency

The Interstate Commerce Commission has announced a proceeding of investigation into the efficiency and economy of railroad management, as to whether expenditures by the carriers for maintenance of equipment have been reasonable, the manner and method in which the business of the carriers is conducted, with special reference to the furnishing of car service, and whether the courses adopted by the carriers in the maintenance of equipment and in providing car service have been efficient and economical and whether the service provided has been reasonably adequate.

Automatic Telephone for P. & R. Shops

The Philadelphia & Reading has installed automatic telephones in its locomotive shops and storehouse at Reading, Pa. The system consists of 60 telephones in the locomotive shop and 17 in the storehouse. The central equipment is located in the main office building at the locomotive shop. It was found advisable to install the automatic system instead of increasing the size of the switchboard and employing an additional operator. It was also found that the new system is able to handle 20 per cent more calls in a given time than were formerly handled by the manual system. The average length of time to complete a call on the authomatic system is 13.3 seconds as compared with 50.6 seconds on the manual.

Belgium Gets Polish Locomotive Order

The Polish government has ordered 100 locomotives from Belgian concerns in the Liége district, according to press dispatches from Brussels. This contract has been predicated upon an agreement by the Belgians to send engineers and skilled workmen to Poland to build and organize railway repair shops.

It is reported also from Berne, Switzerland, that the Swiss Federal Railways have sold to a syndicate 200 steam locomotives which were withdrawn from service due to electrification. This syndicate, it is said, has received a bid from Russia for 50 of these locomotives.

N. Y. C. Locomotive 999 Not to Be Scrapped

Locomotive 999 of the New York Central, which was exhibited at the World's Fair in Chicago in 1893, is to be preserved as a historical relic, and will be placed on exhibition at some prominent place, along with the DeWitt Clinton, of 1831. The "999" was built in the West Albany shops in 1892 and was designed by the late William Buchanan, for many years superintendent of motive power of the New York Central. Its well-known high speed records, in 1893, were made by Charles Hogan, on the Empire State Express, on a run when the engine hauled the train through from New York to Buffalo, 440 miles; and the best speeds were made in the last 70 miles. After service on the Empire State Express for a number of years, this engine was renumbered and relegated to more humble duty. In the summer of 1920 it was taken from its regular run on the Pennsylvania division and was restored to all its pristine glory with silver lettering, to haul the

DeWitt Clinton train to Chicago for exhibition at the Pageant of Progress. It is now stored at Utica awaiting the time when it will be placed on exhibition either at Grand Central Terminal, New York, or some other suitable place.

Larger Appropriations for I. C. C.

A larger appropriation for the Interstate Commerce Commission for the fiscal year 1924 than that allowed by the House of Representatives or that recommended by the Bureau of the Budget was recommended to the Senate on January 17 in the report of the Senate appropriations committee on the independent offices appropriation bill. The House had passed the bill providing for an appropriation of $4,564,500 for the commission as recommended by the House appropriations committee, an amendment to increase the appropriation for valuation work from $1,000,000 to $1,280,000 having been rejected. The Senate committee, however, proposed an increase of $250,000 for valuation work, $200,000 for general expenses and $50,000 for safety work.

The Southeastern Carmen's Interchange Association

The Southeastern Carmen's Interchange Association is the name of an organization which is being formed by men in the Atlantic and Gulf States from Maryland to Louisiana, inclusive, and including also Tennessee, for the purpose of promoting efficiency in the work of the interchange inspectors and also to stimulate proficiency in dealing with the M. C. B. rules.

At a meeting held recently in Washington, D. C., J. A. Masters was chosen secretary-treasurer of the association. Mr. Masters is billing instructor on the Seaboard Air Line, at Portsmouth, Va. He expects, in the near future, to announce a meeting to form a permanent organization to be held at Atlanta, Ga.

It is proposed that all men having to do with the building or the maintenance of either passenger or freight cars shall be eligible to membership.

Consolidation Completed on Northeastern Group of Railways in Britain

The consolidation of the railways of the Northeastern group in Great Britain has been completed, and the new company will be known as the London & North Eastern Railway. The principal companies which have been merged to form this road are the North Eastern, the Great Central, the Great Eastern, the Great Northern, the Hull & Barnsley, the North British and the Great North of Scotland.

All the railways of Great Britain are merged into four regional systems. Details of the organization of the Northwestern, Western and Southern groups have not, however, advanced as far as have those concerning the Northeastern.

Gasoline Substitute on South African Railways

The South African Railways have just awarded to the Natal By-Products, Ltd., manufacturers of "Natalite," a gasoline substitute, a six months' contract for motor fuel for use throughout their motor transport service, according to a report to the Department of Commerce. Natalite, which is a sugarcane distillate made largely from waste materials, will be supplied to the South African Railways at one shilling four pence per imperial gallon; that is, 26.7 cents per U. S. gallon, free on rail at Mearbank, near Durban. It is understood that this is about one-third under the lowest bid for gasoline. The producers of Natalite claim that their product is 90 per cent efficient as compared with gasoline, and it is evident that even discounting this figure, the substitute must be reckoned with in the future. This is the first large contract that has been secured by any substitute, and the outcome of the trial will be awaited with interest.

Cars and Locomotives Ordered and Received in 1922

The number of freight cars actually installed in service or ordered for future delivery from car builders during the calendar year 1922 was 145,553, as compared with 69,436 during 1921, according to reports received by the Car Service Division of the American Railway Association.

The reports showed 77,221 freight cars actually placed in service in 1922 or 7,784 more than were both ordered and installed the year before. On January 1, unfilled orders called for the delivery of 68,332. The reports also showed that in 1922, a total of 2,824 locomotives were actually installed or had been ordered from locomotive builders. This exceeded the number installed and on order during 1921 by 1,442. During 1922, 1,379 locomotives were actually installed in service, only three less than the total number installed or on order the year before. On January 1 this year unfilled orders called for the delivery of 1,445 locomotives.

French-Built Electric Locomotive Undergoes Test

A trial run of a French built electric locomotive was recently conducted by the French Ministry of Public Works. This locomotive is the first of a series of 50 which are to be built on a standardized design for railroad service between Dax and Toulouse, a distance of 220 miles. They will be constructed by the Société des Construction Mécaniques, which recently established works at Tarbes where 900 men are now employed.

It is expected that the section of the Midi Railway between Dax and Toulouse will be completely electrified during 1923. Progressively the whole of the Midi, P. L. M. and Orleans systems, representing a total of about 5,750 miles of line, will be similarly transformed. This scheme for the electrification of the railways is being carried out in conjunction with the undertaking for the utilization of the rivers Rhone and Dordogne for the development of electric power, generally. The substitution of electricity for steam as a motive power on the railroads will enable France, according to official estimates, to reduce her imports of coal by about 3,000,000 tons a year.

Locomotive Output for December and for 1922

The shipments of locomotives in December, as compiled by the Department of Commerce from reports to the Bureau of the Census from the principal manufacturers, were the largest since January, 1921, and amounted to 210 locomotives. Unfilled orders on December 31 amounted to 1,592 locomotives, a slight decline from the previous month. Total shipments of locomotives for the year 1922 were smaller than for 1921 on account of the decline in foreign shipments. The following table compares the December figures and the complete yearly totals for 1921 and 1922, in number of locomotives.

	December 1922	December 1921	Year 1922	Year 1921
Shipments:				
Domestic	194	30	1,056	830
Foreign	16	59	218	519
Total	210	89	1,274	1,349
Unfilled Orders:				
Domestic	1,498	143	.....	.....
Foreign	94	122	.....	.....
Total	1,592	265	.....	.....

Effect of Manganese on Steel

A method of preparing very pure iron has been developed at the Bureau of Standards, and with this iron as a base various commercial steels and other iron alloys have been made for the purpose of testing them without the complicating effect of impurities which are usually present in commercial iron and steel. These facts are set forth in Scientific Paper No. 464 of the Bureau of Standards, Washington, D. C., which is the third of a series, and deals with the effect of manganese on the structure and properties of the steel.

The use of manganese as a strengthening agent, in addition to the carbon, is the subject with which the investigation was chiefly concerned. Manganese is also used as a deoxidizer and as a desulphurizer, but these uses are better understood.

The use of higher percentages of manganese for producing high tensile properties in low and medium carbon steels has been recommended at times by various metallurgists, and to some extent such recommendations have been carried out in commercial practice. The results obtained in this investigation of the structural effects of manganese in steel strongly confirm such recommendations.

The general effect of manganese may be concisely described as a "restraining influence," so that the pearlite or carbon-bearing constituent of steel, even after annealing exists in a very fine grained condition if considerable manganese is present. In this respect the steel resembles in structure the condition which usually obtains in similar steels of low manganese content after rather rapid cooling, for example, air-cooling. The mechanical properties of the an-

nealed high manganese steel are quite similar to those obtained in the lower manganese steel by cooling it more quickly.

Ordinary carbon steel containing approximately 0.90 per cent carbon is termed by metallurgists, "eutectoid" steel, since it presents a uniform structure of pearlite. For many purposes such a steel is the best one to use. An additional effect of manganese upon steel is to shift the eutectoid composition to lower carbon contents by approximately 0.12 per cent for each per cent of manganese.

Manganese also appears to have a very noticeable effect upon the rate at which high carbon steels, such as carbon tool steels and file steels, assume the granular or "spheroidized" state—a condition which for many purposes is very desirable. Manganese exerts its characteristic retarding influence upon this change.

B. of L. E. to Open Bank in New York

The Brotherhood of Locomotive Engineers, having acquired a substantial interest in the Empire Trust Company of New York, will soon apply for a charter for a bank to be opened in New York City, according to an announcement made by Grand Chief Warren S. Stone of the brotherhood.

The new bank, it is said, will be conducted on the co-operative principle the same as the brotherhood's Cleveland bank, which has been remarkably successful thus far. The brotherhood and its members will own all the stock of the new institution. The name of the proposed bank and its capitalization will not be made known until the charter is applied for. It is said that the new bank will have several branches in various parts of the city.

The Central Trades and Labor Council of New York for a time had planned to join with the engineers in this banking venture but later decided to start a bank of their own. They have, accordingly, applied for a state charter for the "Federated Trust Company," capitalized at $2,000,000, and have retained W. F. McCaleb, formerly manager of the engineers' Cleveland bank, to direct their institution for them.

British Firms Secure South African Electrification Contracts

A number of British firms have secured the contracts for the railway electrification in Natal, South Africa. The total expenditure involved is placed at £4,500,000. Among the firms participating are: Metropolitan-Vickers Electrical Company, Ltd.; C. A. Parsons & Co., Ltd.; Babcock & Wilcox, Ltd.; British Thomson-Houston Company, Ltd.; Telegraph Manufacturing Company; A. Reyrolle & Co., Ltd.; South African General Electric Company. For the automatic telephone exchange equipment contracts aggregating £100,000 have been awarded to Messrs. Siemens Brothers & Co., Ltd., of Woolwich, England.

The contracts placed with the Metropolitan-Vickers Company include seventy-eight 3,000-volt, direct-current electric locomotives, according to the Times (London) Trade Supplement for November 25, 1922. The electrical equipment for the locomotives will be built at the Sheffield works of the Vickers Company. The section of railway to be electrified extends from Glencoe to Pietermaritzburg, a distance of about 200 miles. The new locomotives are expected to be capable of making a round trip from Ladysmith to Pietermaritzburg once every twenty-four hours for six days a week, the distance being 129 miles each way.

MEETINGS AND CONVENTIONS

Air Brake Association

The Hotel Albany has been selected as the convention headquarters for the 30th annual meeting of the Air Brake Association in Denver, Col., May 1, 2, 3, 4, 1923.

Master Boiler Makers' Association

Announcement has been made that Hotel Tuller, Detroit, Mich., has been selected as the headquarters and meeting place for the 14th annual convention of the Master Boiler Makers' Association, May 22 to 25 inclusive, 1923.

1923 Meeting of A. S. T. M.

The twenty-sixth annual meeting of the American Society for Testing Materials will be held at the Chalfonte-Haddon Hall Hotel, Atlantic City, N. J., beginning on Monday, June 25, and ending on either Friday or Saturday of that week, depending on the development of the program.

Locomotive Design—A. S. M. E.

A paper on Recent Improvements in Steam Locomotive Design will be presented before the Eastern New York section of the American Society of Mechanical Engineers by Mr. Ashworth of the American Locomotive Company at a meeting to be held in Edison Hall, Schenectady, N. Y., on February 23. The paper will be illustrated with lantern slides and moving pictures.

Mechanical Division of the A. R. A.

The Mechanical Division of the American Railway Association will hold its annual meeting in Chicago, beginning on Wednesday, June 20. Sessions will be continued through two or three days, or until the business on the docket is disposed of. Secretary V. R. Hawthorne expects to issue the detailed program within a few weeks.

Officers of the Central Railway Club

At the meeting of the Central Railway Club held in Buffalo on January 11, the following officers were elected for the year 1923: President, C. L. McIlvaine, superintendent motive power, Pennsylvania Railroad, Buffalo, N. Y.; first vice-president, W. O. Thompson, general superintendent rolling stock, New York Central, Buffalo, N. Y.; second vice-president, A. R. Ayers, superintendent motive power, New York, Chicago & St. Louis, Cleveland, Ohio; third vice-president, E. V. Williams, superintendent of motive power, Buffalo, Rochester & Pittsburgh, Du Bois, Pa. The executive members elected were: John N. Gaiser, general foreman, Erie Railroad, Buffalo, N. Y.; T. J. O'Donnell, chief interchange inspector, Buffalo, N. Y.; Arthur N. Dugan, vice-president, Bronze Metal Company, New York, N. Y.

The following list gives names of secretaries, dates of next or regular meetings and places of meeting of mechanical associations and railroad clubs:

AIR-BRAKE ASSOCIATION.—F. F. Nellis, Room 3014, 165 Broadway, New York City. 1923 annual convention; Denver, first Tuesday in May.

AMERICAN RAILROAD MASTER TINNERS', COPPERSMITHS' AND PIPEFITTERS' ASSOCIATION.—C. Borcherdt, 202 North Hamilton Ave., Chicago.

AMERICAN RAILWAY ASOCIATION, DIVISION V—MECHANICAL.—V. R. Hawthorne, 431 South Dearborn St., Chicago. Next meeting Chicago, June 20, 1923.

DIVISION V—EQUIPMENT PAINTING DIVISION.—V. R. Hawthorne, Chicago.

DIVISION VI—PURCHASES AND STORES.—W. J. FARRELL, 30 Vesey St., New York. Next meeting, Chicago, May 22, 1923.

AMERICAN RAILWAY TOOL FOREMEN'S ASSOCIATION.—R. D. Fletcher, 1145 E. Marquette Road, Chicago.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Calvin W. Rice, 29 W. Thirty-ninth St., New York. Railroad Division, A. F. Stuebing, 2201 Woolworth Building, New York.

AMERICAN SOCIETY FOR TESTING MATERIALS.—C. L. Warwick, University of Pennsylvania, Philadelphia, Pa.; 1923 annual convention, Atlantic City, June 25, 1923.

AMERICAN SOCIETY FOR STEEL TREATING.—W. H. Eiseman, 4600 Prospect Ave., Cleveland, Ohio. Sectional meeting, February 8 and 9, City Club, Chicago.

ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.—Joseph A. Andreucetti, C. & N. W., Room 411, C. & N. W. Station, Chicago, Ill.

CANADIAN RAILWAY CLUB.—W. A. Booth, 53 Rushbrook St., Montreal, Que. Next meeting March 8.

CAR FOREMEN'S ASSOCIATION OF CHICAGO.—Aaron Kline, 626 N. Pine Ave., Chicago, Ill. Meeting second Monday in month, except June, July and August, Great Northern Hotel, Chicago, Ill.

CAR FOREMEN'S ASSOCIATION OF ST. LOUIS.—Thomas B. Koeneke, 604 Federal Reserve Bank Building, St. Louis, Mo.

CENTRAL RAILWAY CLUB.—H. D. Vought, 26 Cortlandt St., New York, N. Y. Next meeting March 8.

CHIEF INTERCHANGE CAR INSPECTORS' AND CAR FOREMEN'S ASSOCIATION.—W. P. Elliott, T. R. R. A. of St. Louis, East St. Louis, Ill.

CINCINNATI RAILWAY CLUB.—W. C. Cooder, Union Central Building, Cincinnati, Ohio.

INTERNATIONAL RAILROAD MASTER BLACKSMITHS' ASSOCIATION.—W. J. Mayer, Michigan Central, 2347 Clark Ave., Detroit, Mich.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.—J. G. Crawford, 702 East Fifty-first St., Chicago, Ill.

INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION.—William Hall, 1061 W. Wabash Ave., Winona, Minn.

MASTER BOILERMAKERS' ASSOCIATION.—Harry D. Vought, 26 Cortlandt St., New York, N. Y.; 1923 annual convention, Detroit, Mich., May 22, 1923.

NEW ENGLAND RAILROAD CLUB.—W. E. Cade, Jr., 683 Atlantic Ave., Boston, Mass.

NEW YORK RAILROAD CLUB.—H. D. Vought, 26 Cortlandt St., New York.

NIAGARA FRONTIER CAR MEN'S ASSOCIATION.—George A. J. Hochgreb, 623 Brisbane Building, Buffalo, N. Y.

PACIFIC RAILWAY CLUB.—W. S. Wollner, 64 Pine St., San Francisco, Cal.

RAILWAY CLUB OF PITTSBURGH.—J. D. Conway, 515 Grandview Ave., Pittsburgh, Pa.

ST. LOUIS RAILWAY CLUB.—B. W. Fruenthal, Union Station, St. Louis, Mo.

TRAVELING ENGINEERS' ASSOCIATION.—W. O. Thompson, 1177 East Ninety-eighth St., Cleveland, Ohio.

WESTERN RAILWAY CLUB.—Bruce V. Crandall 605 North Michigan Ave., Chicago.

SUPPLY TRADE NOTES

F. W. Stubbs, mechanical engineer of the Chicago Great Western, has been appointed mechanical engineer of the Standard Stoker Company, with headquarters at Erie, Pa.

J. H. Schwacke, manager of William Sellers & Co., Inc., Philadelphia, Pa., has been elected president. Mr. Schwacke has been in the service of this company for more than 60 years.

Major J. L. Hays has joined the sales organization of the Safety Car Heating & Lighting Company, New Haven, Conn., as commercial engineer, and will be located at the Philadelphia Pa., office. Major Hays graduated from Lehigh University in 1909 with a degree of electrical engineer and then joined the electrical department staff of the Baltimore & Ohio, working successively as mechanic, draughtsman, inspector, general foreman and assistant engineer. He later served with the Seaboard Air Line as electrical engineer until he was commissioned as a major in the Quartermaster's Corps at the beginning of the war, in charge of the electrical section of the engineering branch, being responsible for electrical construction for the army in the United States. At the conclusion of the war he joined the Stone-Franklin Company as electrical engineer, serving until the Safety Car Heating & Lighting Company absorbed the car lighting interests of the Stone-Franklin Company on January 1 of this year.

Maj. J. L. Hays

S. G. Downs, general sales manager of the Westinghouse Air Brake Company, Wilmerding, Pa., has been elected vice-president in general charge of sales and commercial activities. Previous to his appointment as general sales manager, he had been president of the Westinghouse Pacific Coast Brake Company, at Emeryville, Cal., and western district manager of the Westinghouse Air Brake Company and the Westinghouse Traction Brake Company. Mr. Down served as general air brake inspector and instructor on the Michigan Central until 1902, and then joined the Westinghouse Air Brake organization. He was for several years instructor on the company's instruction car and later was appointed mechanical expert with headquarters in Chicago. In 1910 he was appointed district engineer and transferred to San Francisco and shortly afterward he was appointed Pacific district manager. He was largely responsible for the organization of the Westinghouse Pacific Coast Brake Company in California, and when it was formed, became vice-president and later president of that company. In 1919 he made an extensive tour of the Far East and established various commercial activities which have resulted in an increased business for the Air Brake Company from the Orient.

S. G. Down

Robert Enos Adreon, president of the American Brake Company and acting southwest district manager of the Westinghouse Air Brake Company, died suddenly of apoplexy on January 6 in St. Louis, Mo.

William N. Shaw, vice-president of the New York Air Brake Company, of New York City, has resigned and in future will devote all his time to the Eisemann Magneto Corporation, Brooklyn, N. Y., of which he has been president for the past four years, and to other interests.

R. E. Terhune has been placed in charge of the Northern New Jersey sales territory of the Uehling Instrument Company, Paterson, N. J. Mr. Terhune was formerly associated with the Uehling Laboratories, and is, therefore, well qualified to co-operate with power plant operators on the important subject of power plant economy.

T. F. Whelan has been appointed special engineer of the Franklin Railway Supply Company with headquarters in Chicago. For 26 years he served as a locomotive engineer and for the past six years was editor of the Brotherhood of Locomotive Engineers Journal. In his new position he will do educational work among railroad employees.

On December 20, 1922, death claimed another of the pioneer machine tool builders, A. B. Landis, who was perhaps best known for his work in developing the Landis grinding and threading machinery. Mr. Landis was born in 1854 and learned his trade as a machinist in the shops of Frank F. and Ezra F. Landis of Lancaster. In 1874 he became a partner of his brother under the firm name of F. F. & A. B. Landis for the manufacture of small stationary engines and portable steam engines. Mr. Landis was for a number of years in charge of the tool department of the Geiser Manufacturing Company, Waynesboro, Pa., where he developed the first Landis grinding machine which was employed in a commercial way. In 1890 a partnership was formed with his brother, F. F. Landis, under the firm name of Landis Brothers for the manufacture of cylindrical grinding machines. In 1903 the Landis Machine Company was organized to manufacture the Landis threading machines and these two companies were largely responsible for the development and growth of the town of Waynesboro. In the fall of 1910 Mr. Landis severed his connection with both the Landis Tool Company and the Landis Machine Company, taking up his residence at Chestnut Hill, Philadelphia, where he opened up an engineering laboratory for the development of many inventions, chief among which was a mechanical speed change mechanism for automobiles, machine tools, etc. In the fall of 1919 he organized the firm of A. B. Landis & Son for the purpose of commercial grinding and the development of mechanical ideas. He was actively connected with this business up to the time of his death, which was very sudden.

A. B. Landis

An announcement has been issued that the Safety Car Heating & Lighting Company has acquired the business of the Stone-Franklin Company, Inc., for the United States and Cuba, and will in the future be in a position to supply Stone-Franklin equipments where required and the necessary spare parts for the maintenance of equipments now in service.

The American Engineering Company, Philadelphia, has taken over the Standard Crane and Hoist Company and the patent and manufacturing rights to the monorail electric hoist with low headroom, formerly known as the Standard. H. S. Valentine, Chief Engineer of the Standard Crane and Hoist Company, brings to the American Engineering Company more than twenty years' experience in the design and manufacture of hoists and the solution of material handling problems in practically every industry. He

is directing the sales, and supervising the manufacture of the hoists. The American Engineering Company has reorganized its No. 1 plant to accommodate the work of building and testing the hoists on a commercial basis.

Major Frank S. Robbins, who recently returned from the Orient after serving as a mechanical adviser for the Inter-Allied Technical Board at Harbin, Manchuria, has joined the forces of the Pittsburgh Testing Laboratory at Pittsburgh, Pa., having been appointed railway representative of this organization. After graduating from Purdue University, Major Robbins began his railroad work in 1900 as a machinist apprentice for the Pennsylvania Railroad at its Meadows shops, and continued in its service until March, 1921. After the time the company's locomotive testing laboratory was opened at Altoona, Major Robbins was assigned to work at that place. Subsequently, he occupied positions as motive power inspector, assistant road foreman of engines, assistant master mechanic and master mechanic, his last appointment being master mechanic of the Pittsburgh Terminal division. During the war, he served with the 19th Engineers and later was commanding officer of the 65th Engineers and acted as superintendent of motive power of the 16th Grand Division of the Transportation Corps.

W. H. Winterrowd has been appointed assistant to the president of Lima Locomotive Works, Inc., with headquarters at New York City. Mr. Winterrowd was born on April 2, 1884, at Hope, Ind. He attended the public schools at Shelbyville, Ind., and was graduated in 1907 from Purdue University. During his college vacations he was employed as a blacksmith's helper on the Lake Erie & Western, at Lima, Ohio, and as a car and air brake repairman on the Pennsylvania, Lines West, at Dennison, Ohio. After graduation in 1907 he became a special apprentice on the Lake Shore & Michigan Southern, and in 1908 he went with the Lake Erie, Alliance & Wheeling as enginehouse foreman at Alliance, Ohio. In 1909 he became night enginehouse foreman of the Lake Shore & Michigan Southern at Youngstown, Ohio, and in 1910 was made roundhouse foreman at Cleveland. Later in the same year he was promoted to assistant to the mechanical engineer of the Lake Shore. Since September, 1912, he has been with the Canadian Pacific at first as mechanical engineer, in 1915 he was appointed assistant chief mechanical engineer and in 1918 was appointed chief mechanical engineer, which position he held to the time of his appointment as above noted. Mr. Winterrowd is active in the Mechanical Section of the American Railway Association, being a member of the General Committee. He is also active in the American Society of Mechanical Engineers. Together with H. H. Vaughan and Frank H. Clark he contributed greatly to the success of the boiler code of the society. Among the papers he has presented is a noteworthy article on refrigerator cars. He has taken particular interest in the railroad section, serving as vice-chairman of the executive committee last year and is still a member of this committee.

W. H. Winterrowd

C. J. Burkholder, supervisor of service of the Franklin Railway Supply Company, Inc., New York, died on December 22 in St. Mary's Hospital, Kansas City, following an operation. Mr. Burkholder was born on May 9, 1870. He began railroad work at Tyrone, Pa., and subsequently was a locomotive fireman and engineman on the Union Pacific. He then went to the Kansas City Southern as a locomotive engineman, later serving consecutively as traveling engineer, trainmaster, general road foreman of engines and division superintendent. He left the Kansas City Southern to become a mechanical representative of the Economy Devices Corporation, which was afterwards merged into the Franklin Railway Supply Company, Inc. During the period of the war, Mr. Burkholder returned to railroad work, leaving the Franklin Railway Supply Company, of which he was then western sales manager, on November 1, 1918, to become master mechanic of the Kansas City Southern. On January 1, 1921, he returned to the Franklin Railway Supply Company as special engineer assigned to work in connection with the locomotive booster, and since the following October was supervisor of service.

The Westinghouse Air Brake Company, Wilmerding, Pa., has made the following appointments in the Eastern district: E. W. Davis, representative at New York of the Westinghouse Traction Brake Company, has been promoted to representative, Westinghouse Air Brake Company and Westinghouse Traction Brake Company, in charge of the Boston, Mass., office. G. H. Martin, mechanical expert for the Westinghouse Traction Brake Company, has been promoted to representative, Westinghouse Air Brake Company and Westinghouse Traction Brake Company, with headquarters at Boston. F. H. Whitney, representative of the Westinghouse Air Brake Company, has been promoted to export representative, Westinghouse Air Brake Company and Westinghouse Traction Brake Company, with headquarters at New York, and H. B. Gardner has been appointed representative, Westinghouse Air Brake Company, reporting to the New York office. Mr. Gardner was formerly with the Locomotive Stoker Company, Pittsburgh, whose service he entered in June, 1916. After serving for some time in the Stoker Company's shops, he was made mechanical expert and during the last few years was attached to the sales department of that company.

Decision in Locomotive Stoker Patent Suit

The United States Circuit Court of Appeals for the Third Circuit, at Philadelphia, on January 3, handed down a decision in the suit of the Locomotive Stoker Company vs. The Elvin Mechanical Stoker Company, which was brought in the United States District Court for the District of Delaware. Infringement was charged of the Gee and the Street patents for locomotive stokers, and Judge Morris, in the District Court, held that there was no infringement of the Gee patent, but that the Street patent was infringed. The Court of Appeals affirmed this decision as to the Gee patent, and reversed it as to the Street patent, holding that neither patent was infringed by The Elvin Mechanical Stoker Company and ordering the suit to be dismissed as to both patents.

TRADE PUBLICATIONS

ELVIN MECHANICAL STOKER.—A Service Hand Book and Shop Manual No. 2 has been issued by The Elvin Mechanical Stoker Company, 50 Church street, New York. This booklet, which is of pocket size and contains 130 pages, describes the various parts of the stoker and gives instructions for operation, inspection and maintenance. A series of plates with part numbers and tables of the proper names of all pieces will be of assistance to those who have to call for or order repair parts.

SELF-OPENING DIE HEADS.—The Eastern Machine Screw Corporation, New Haven, Conn., has published a pocket size edition of its ninety-six page catalog, descriptive of the H&G self-operating die heads. The book contains fifty-six illustrations and deals in a most interesting manner with the design, workmanship and adaptability of H&G die heads. The publication contains a great deal of information and many tables of value to the manufacturer or whoever is cutting threads. The book has been put out in this size especially for the man in the shop and to make wider distribution of this data possible.

PROTECTING PIPE AGAINST INTERNAL CORROSION.—In recent years engineers have given considerable study to eliminating the rapid corrosion which occurs in iron and steel pipes carrying hot water under pressure. The result of recent research on this subject is well set forth in a bulletin entitled "The Protection of Pipe Against Internal Corrosion" recently issued by the National Tube Company, Pittsburgh, Pa. The bulletin contains a number of papers on the fundamental causes of corrosion, details of the mechanism of corrosion, practical means of preventing corrosion and typical results of corrosion prevention. The methods discussed include mechanical de-aerating of water, fixing free oxygen by chemical combination, combined mechanical and chemical deaeration and the use of protective coatings.

EQUIPMENT AND SHOPS

Locomotive Orders

The Canadian National has ordered 43 locomotives from the American Locomotive Company.

The Grand Trunk has ordered eight switching locomotives from the Lima Locomotive Works.

The Virginian has ordered 15 2-8-8-2 Mallet type locomotives from the American Locomotive Company.

The Canadian Pacific has ordered 16 4-6-2 type locomotives from the American Locomotive Company.

The St. Louis Southwestern has ordered 15 2-8-0 type locomotives from the Baldwin Locomotive Works.

The Chicago & Eastern Illinois has ordered 10 2-8-2 type locomotives from the American Locomotive Company.

The Central of New Jersey has ordered six 2-6-2 type suburban locomotives from the Baldwin Locomotive Works.

The New York, Chicago & St. Louis has ordered six 4-6-2 type locomotives from the American Locomotive Company.

The Louisville, Henderson & St. Louis has ordered five 4-6-2 type locomotives from the American Locomotive Company.

The Illinois Central has ordered 35 2-8-2 type from the Baldwin Locomotive Works and 15 4-8-2 type from the American Locomotive Company.

The Chicago & North Western has ordered 18 2-8-2 type, 12 4-6-2 type and 20 0-6-0 type switching locomotives from the American Locomotive Company.

The Central of Georgia has ordered five 4-8-2 type locomotives from the American Locomotive Company and 10 2-8-2 type from the Lima Locomotive Works.

The Union Pacific has ordered 18 2-10-2 type locomotives from the Baldwin Locomotive Works; 37 2-10-2 type from the Lima Locomotive Works, and 18 2-10-2 type also 5 Mallet type from the American Locomotive Company.

The Pennsylvania has authorized the placing of orders for 300 locomotives to be constructed and delivered during the present year. Of the total number, 125 will be constructed at the company's Altoona Works. They will consist of 42 heavy passenger locomotives, 40 medium weight passenger locomotives, and 43 switching locomotives. The remainder of the authorization covers 175 heavy freight engines. Arrangements for construction of 100 of these have been made with the Baldwin Locomotive Works. The allotment of the other 75 will be determined later.

Passenger Car Orders

The Baltimore & Ohio has ordered four dining cars from the Pullman Company.

The Union Pacific has ordered 21 baggage and mail cars from the Standard Steel Car Company.

The Missouri Pacific has ordered 17 steel coaches from the American Car & Foundry Company.

The New York Central is having 60 milk cars built at the shops of the Merchants' Dispatch and is having a dynamometer car built in its West Albany shops.

The American Railway Express has ordered 150 express refrigerator cars from the General American Car Company. These are in addition to the order for 150 placed last year.

The Union Pacific has ordered 200 50-ft. refrigerator cars equipped for passenger train service from the American Car & Foundry Company and 100 from the General American Car Company.

The Canadian National has ordered 50 express refrigerator cars and 10 baggage cars from the National Steel Car Corporation; 10 mail and express cars 35 coaches, 20 sleeping cars and 20 baggage cars from the Canadian Car & Foundry Company.

Freight Car Orders

The Illinois Central has ordered 500 ballast cars from the Rodger Ballast Car Company.

The Southern Pacific has ordered 575 general service cars from the General American Car Company.

The Union Tank Car Company has ordered 500 tank cars from the American Car & Foundry Company.

The Atlanta & West Point has ordered 150 hopper cars of 55 tons' capacity from the American Car & Foundry Company.

The Phillips Petroleum Company, Bartlesville, Okla., has ordered 100 tank cars from the Standard Tank Car Company.

A. B. C. Refrigerator Transit Company, New York City, is having 500 refrigerator cars built at the shops of the Merchants' Dispatch.

The Chicago, Indianapolis & Louisville has ordered 300 steel underframes and steel superstructures for gondola cars from the Pullman Company.

The Central of Georgia has ordered 100 stock cars, 300 hopper cars, 200 composite gondola cars and 500 box cars from the Chickasaw Shipbuilding Company.

The Great Northern has ordered 1,000 U. S. R. A. standard box cars from the Pullman Company and has also ordered 500 automobile cars from the American Car & Foundry Company.

The Chicago, Rock Island & Pacific has ordered 500 automobile cars from the Bettendorf Company, 250 flat cars from the American Car & Foundry Company and 250 refrigerator cars from the General American Car Company.

The United Fruit Company has ordered 100 flat cars of 20 tons' capacity from the Magor Car Corporation for use on the Truxillo Railroad, Honduras. A contract for 10 flat cars of 20 tons' capacity has been given to the Gregg Company, Ltd.

The Chicago & North Western has ordered 3,000 single sheath box cars of 80,000-lb. capacity, divided equally between the General American Car Company, the American Car & Foundry Company and the Western Steel Car Company, and has placed an order for 200 steel underframe milk cars with the Pullman Company.

The Canadian National has ordered 1,000 box cars from the National Steel Car Corporation; 1,000 box cars and 100 ballast cars from the Canadian Car & Foundry Company; 500 box cars, 100 general service cars and 100 steel coal cars from the Eastern Car Company, and will also have 276 general service cars repaired at the shops of the Eastern Car Company.

The Baltimore & Ohio has ordered 4,000 all steel hopper cars from the following companies: Pressed Steel Car Company 1,500, American Car & Foundry Company 1,000, Standard Steel Car Company 500, Youngstown Steel Car Company 500, and Ralston Steel Car Company 500. Contracts were also let for the 1,000 steel gondola cars to the Cambria Steel Car Company and for 1,000 box cars to the Standard Steel Car Company and 1,000 box cars to the Liberty Car & Equipment Company.

Machinery and Tools

The Southern Pacific has placed an order for an axle lathe.

The Louisville & Nashville has placed an order for a 40-in. planer.

The Missouri Pacific has ordered a 200-ton locomotive hoist from the Whiting Corporation.

The Pennsylvania Coal Company has ordered a rotary shear from Joseph T. Ryerson & Son.

The Texas & Pacific has placed orders for a set of bending rolls, also for two plate flanging clamps.

The New York, New Haven & Hartford has placed orders for a 2,000-lb. steam hammer and a 36-in. lathe.

The Kansas City Southern has ordered one 250-ton, 70-ft. traveling crane and one 15-ton locomotive crane from the Whiting Corporation, Harvey, Ill.

The Delaware, Lackawanna & Western has placed orders for tools as follows: A 54-in. Chambersburg 500-ton, single end car wheel press; one Winton 6-in. and one Winton 4-in. double spindle centering machine; two 14-in. Allen double spindle sensitive drilling

machines; one Chicago steel power bending brake; two 42-in. vertical drilling machines; one 72-in. Bement duplex control, motor driven boring and milling machine; one Niles-Bement-Pond rapid production standard 48-in. planer; two Ryerson-Conradson 5-ft., high power, plain radial drills; two Ryerson-Conradson 30-in. selective geared engine lathes; two Ryerson-Conradson 17-in. selective geared hand portable engine lathes; seven 21-in. Ryerson-Conradson selective geared head engine lathes; one McCabe pneumatic flanging machine; one 36-in. Morton new type, heavy duty draw cut railroad shaper; one Buffalo universal No. 25 slitting shear, punch and bar cutter; one Brown & Sharpe No. 5B heavy plain milling machine; four Gould & Eberhard universal type crank shapers; one Warner & Swazey No. 2A universal hollow hexagon turret lathe.

Shops and Terminals

The St. Louis-San Francisco is constructing an 80-ft. by 100-ft. tank shop with company forces at Sherman, Tex.

The Missouri, Kansas & Texas has awarded a contract to Joseph E. Nelson & Sons, Chicago, for the construction of a six-stall addition to the roundhouse and a new power house at Franklin, Mo.

The Southern Pacific is constructing with company forces two 40-ft. by 60-ft. one-story, frame shop buildings, with concrete floors, to cost approximately $11,000. This company is also constructing a 44-ft. by 625-ft. frame car repair shop to cost approximately $26,000.

The Union Pacific has completed plans for the construction of new shop and yard facilities at Los Angeles, Cal., and will begin work on the first unit of the improvements at once. The new terminal is to be located between Jaboneria road and Telegraph road, south of Ninth street on the main line in the eastern part of Los Angeles. The principal structures of the first unit, which will cost approximately $1,750,000, are a 20-stall brick engine house, a 100-ft. turntable, a locomotive erecting and boiler shop, a coach, car and blacksmith shop and a car repair shop with related facilities, including transfer table, storehouse, lumber and iron sheds, office buildings, power house, oil house and oil supply system.

PERSONAL MENTION

General

J. W. Small, formerly superintendent of motive power of the Seaboard Air Line and later superintendent of motive power and shops of the Cuba Railroad, has been appointed chief mechanical officer of the Chesapeake & Ohio. He will have entire charge of the mechanical department and his headquarters will be at Richmond, Va. Mr. Small was born on September 24, 1870, at Chatham, Ont., and was educated in the high schools of that city and at the Collegiate Institute. He began railway work in 1887 as a machinist's apprentice on the Northern Pacific. In 1892 he went to Pocatello, Idaho, as a machinist for the Oregon Short Line. The following year he went to Tacoma, Wash., as a machinist for the Northern Pacific. Later in the same year he entered the service of the Southern Pacific as a machinist and served subsequently as gang foreman, roundhouse foreman, assistant master mechanic and master mechanic for that company. In 1906 he became superintendent of motive power of the Mexican lines of the Southern Pacific. In 1910 he went to the Kansas City Southern in a similiar capacity and the following year became superintendent of motive power for the Missouri Pacific. The same year he went with the Sunset Central Lines (Galveston, Harrisburg & San Antonio, Houston & Texas Central, Morgan's Louisiana & Texas, Texas & New Orleans, etc.) as assistant general manager. In 1913 he was appointed superintendent of motive power of the Seaboard Air Line. Mr. Small, during federal control, served first as mechanical assistant to the regional director, Southern region, and later as mechanical staff officer to the regional director of the same region. In April, 1921, he was appointed superintendent of motive power of the Cuba Railroad with headquarters at Camaguey, Cuba, from which position he resigned in July, 1922.

J. W. Small

A. L. Moler has been appointed mechanical inspector of the Chesapeake & Ohio, reporting directly to the chief mechanical officer.

Robert Collett, superintendent of fuel and locomotive performance, has been appointed fuel agent of the St. Louis-San Francisco, with headquarters at St. Louis.

C. C. Cannon, roundhouse foreman of the Chicago Great Western at Kansas City, Mo., has been promoted to system fuel supervisor, with headquarters at Chicago.

R. W. Retterer, acting mechanical engineer of the Cleveland, Cincinnati, Chicago & St. Louis, with headquarters at Cincinnati, Ohio, has been appointed mechanical engineer with the same headquarters.

George H. Rusbuldt, valuation engineer of the mechanical department of the Chicago Great Western with headquarters at Oelwein, Ia., has been appointed mechanical engineer, succeeding F. W. Stubbs, resigned.

Master Mechanics and Road Foremen

J. L. Brennan has been appointed acting master mechanic of the Delaware & Hudson with headquarters at Carbondale, Pa.

C. H. Womack has been appointed road foreman of engines of the Chesapeake & Ohio with headquarters at Peach Creek, W. Va.

J. J. Callaham has been appointed road foreman of engines of the Chesapeake & Ohio with headquarters at Huntington, W. Va.

A. R. Numbers has been appointed road foreman of engines of the Eastern division of the Atchison, Topeka & Santa Fe, with headquarters at Ottawa, Kan.

J. J. Mellen has been appointed master mechanic of the Cincinnati Northern, with headquarters at Van Wert, Ohio, succeeding W. R. Beck, who has resigned.

Shop and Enginehouse

W. H. Piper, who has had charge of the enginehouse at Mifflin, Pa., for several years, has been appointed foreman of the Enola, Pa., enginehouse of the Pennsylvania, succeeding P. L. Binghaman, transferred.

P. L. Binghaman, foreman of the Enola, Pa., enginehouse of the Pennsylvania, has been appointed foreman of roundhouse No. 2 at Harrisburg, Pa., succeeding W. H. Bickley, who has been transferred to the new Juniata shops.

Purchasing and Stores

H. C. Stevens has been appointed general storekeeper of the Wabash, succeeding R. F. Augsburger, who has resigned.

W. H. King, Jr., has been appointed assistant to vice-president of the Seaboard Air Line with headquarters at Norfolk, Va. He will perform such duties in connection with purchases as may be assigned to him by Vice-President M. J. Caples, to whom the direction of the department of purchases and stores has been assigned in addition to his other duties. The office of general purchasing agent has been abolished.

Obituary

C. E. Nutter, electrical engineer of the Atchison, Topeka & Santa Fe, with headquarters at Topeka, Kan., died on January 20.

H. McClure, general inspector of freight car equipment of the Missouri Pacific, died of heart disease on January 5, while at work in his office at St. Louis, Mo.